BLM LIBRARY
88030700

Dickinson

GEOLOGICAL SURVEY CIRCULAR 720

Mineral Resource Management of the Outer Continental Shelf

TN 263 .A2
1859434

Mineral Resource Management of the Outer Continental Shelf

By M. V. Adams, C. B. John, R. F. Kelly
A. E. LaPointe, and R. W. Meurer

GEOLOGICAL SURVEY CIRCULAR 720

Leasing procedures, evaluation of resources, and supervision of production operations on leased lands of the Outer Continental Shelf

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

1975

United States Department of the Interior

Geological Survey

V. E. McKelvey, *Director*

Library of Congress catalog card no. 75-600041

Free on application to the U.S. Geological Survey, National Center, Reston, Virginia 22092

CONTENTS

	Page
Abstract	1
Introduction	1
Legislative background	1
Outer Continental Shelf	2
Historical background	2
Statistical background	3
Lease sales	3
Production and royalty value	4
Land and Water Conservation Fund	4
Leasing procedure for the Outer Continental Shelf	7
Leasing schedule	8
Collection of geological and geophysical data	8
Geological activity	9
Geophysical activity	9
Environmental baseline data studies	9
Resource reports	10
Call for nominations	10
Tract selection	10
Environmental Impact Statement	10
Draft statement	10
Public hearing	11
Final statement	11
Decision by the Secretary	11
Notice of sale	11
Detailed resource evaluation of each tract	11
Lease sale	11
Decision to accept or reject bids	11
Issuance of lease	12
Coordination with state and federal agencies	12
Resource evaluation	12
Geophysics	12
Regional mapping	13
Detailed mapping	13
Bright spot analysis	14
High resolution surveys	14
Geology	14
Data analysis and support	14
Reserve estimates	14
Tract evaluation	15
Engineering	15
Management of leased lands	16
Oil and gas lease contract	16
Safety and pollution control	16
Supervision of drilling operations	16
Supervision of production operations	18
Field inspection	23
Resource conservation	24
Unitization	24
Production control	25
Royalty accounting	25
Efforts to increase operational margin of safety	25
Future Outer Continental Shelf activity	26
Statistical background	26
Areal extent and location	27
Lead time	30
Conclusions	31
Selected references	31

ILLUSTRATIONS

		Page
FIGURE 1.	Outer Continental Shelf royalty revenue and funding of the Land and Water Conservation Fund, by fiscal years 1969 to 1974	8
2.	Schematic diagram of a marine seismic prospecting system	13
3.	Multifold seismic reflection data (standard processing)	15
4.	Multifold seismic reflection data (high fidelity—bright spot—processing)	15
5.	Self-contained fixed drilling and production platform	17
6.	Jack-up mobile drilling platform	19
7.	Floating mobile drilling platform	20
8.	Semi-submersible mobile drilling platform	21
9.	Blowout preventer assembly for installation on the ocean floor	22
10.	Schematic diagram showing casing program and production safety system of a typical 12,000-foot well, Gulf of Mexico	23
11.	Profile of the continental margin	30

TABLES

		Page
TABLE 1.	Outer Continental Shelf lease sales by years, states, minerals	3
2.	Summary of Outer Continental Shelf lease sales, October 13, 1954 through December 20, 1973, by state and mineral	4
3.	Outer Continental Shelf producing and non-producing leases (oil, gas, salt, and sulfur) under supervision, by years, as of December 31	4
4.	Outer Continental Shelf producing and non-producing leases (oil, gas, salt, and sulfur) under supervision as of December 31, 1973, by states and products	4
5.	Outer Continental Shelf revenue and production value, percentage cumulative revenue of cumulative production value, calendar years 1953–1973	5
6.	Cumulative bonuses, minimum royalties, rentals, shut-in gas payments, and royalties, Outer Continental Shelf, by states, August 7, 1954 to December 31, 1973	5
7.	Land and Water Conservation Fund planning, acquisition, and development grants to states as of June 30, 1974	6
8.	Funding of the Land and Water Conservation Fund by Outer Continental Shelf receipts, fiscal years 1969 to 1974	7
9.	Outer Continental Shelf receipts, fiscal years 1969 to 1974	7
10.	Distribution of ratios of incidents of non-compliance to potential items of non-compliance by event class, observed during December 1970 through April 1974 inspections of production sites	24
11.	Unit plans and percentage of unitized production Outer Continental Shelf, calendar years 1956 to 1973	26
12.	Total offshore state and federal oil and condensate production	27
13.	Total offshore state and federal gas production	28
14.	Total United States and Outer Continental Shelf production of crude oil and condensate, and gas, and percentage of OCS production of total United States production	29
15.	Continental seabeds adjacent to the United States	30

SYSTEM OF MEASUREMENT UNITS

[The following report uses the English system of units. The English units can be converted to metric units by multiplying by the factors given in the following list]

To convert English unit	*Multiply by*	*To obtain Metric unit*
Acres	0.4047	Hectares (ha).
	4.047×10^{-3}	Square kilometres (km^2).
Barrels (oil)	0.159	Cubic metres (m^3).
	1.590×10^{2}	Litres (l).
Cubic feet	2.832×10^{-2}	Cubic metres (m^3).
	28.32	Litres (l).
Feet	0.3048	Metres (m).
Miles, statute	1.609	Kilometres (km).
geographical or nautical	1.852	Kilometres (km).
Square miles, statute	2.590	Square kilometres (km^2).

Mineral Resource Management of the Outer Continental Shelf

By Maurice V. Adams, Charles B. John, Robert F. Kelly
Alfred E. LaPointe, *and* Robert W. Meurer

ABSTRACT

An important function of the Geological Survey is the evaluation and management of the mineral resources of the Outer Continental Shelf, particularly with respect to oil and gas, salt, and sulfur.

Production of oil and gas from the Outer Continental Shelf of the United States has increased substantially over the past 20 years and represents an increasing percentage of total United States production. As discovery of major onshore production of oil and gas has become more difficult, the search has moved into the surrounding waters where submerged sedimentary formations are conducive to the accumulation of oil and gas. Increased energy demands of recent years have accelerated the pace of offshore operations with a corresponding improvement in technology as exploration and development have proceeded farther from shore and into deeper water. While improved technology and enforcement of more stringent regulations have made offshore operations safer, it is unrealistic to believe that completely accident-free operations can ever be achieved.

Only slightly more than six percent of the world's continental terrace is adjacent to the United States, but less than one percent has been explored for oil and gas. Since the lead time for the development of offshore oil and gas resources can be as much as a decade, they do not provide an immediate energy supply but should be viewed in the light of a near-term source with a potential of becoming a medium-range source of supply pending the development of alternative energy sources.

Revenues from the Outer Continental Shelf are deposited to the general fund of the United States Treasury. A major portion of these funds is allocated to the Land and Water Conservation Fund, the largest Federal grant-in-aid program of assistance to States, counties, and cities for the acquisition and development of public parks, open space, and recreation lands and water.

INTRODUCTION

The Geological Survey is a bureau-level organization within the Department of the Interior that was established by the Act of March 3, 1879 (20 Stat. 394; 43 U.S.C. 31), which provided for "the classification of the public lands and the examination of the geological structure, mineral resources, and products of the national domain."

Subsequent legislation established that:

> The broad objectives of the Geological Survey are to perform surveys, investigations, and research covering topography, geology, and the mineral and water resources of the United States; classify land as to mineral character and water and power resources; enforce departmental regulations applicable to oil, gas, and other mining leases, permits, licenses, development contracts, and gas storage contracts; and publish and disseminate data relative to the foregoing activities.

The Geological Survey accomplishes a portion of its objectives on the Outer Continental Shelf through the delegation of certain activities to its Conservation Division which:

> * * * classifies Federal lands as to their value for leasable minerals; supervises the operations of private industry on oil and gas leases on the Outer Continental Shelf to ensure maximum utilization and prevent waste of resources, to limit environmental damage and pollution and to protect public health and safety; assures the public a fair market return for the disposition of its mineral resources; establishes maximum rates of production for producing wells; maintains production accounts and collects royalties; and provides certain Federal agencies geologic and engineering advice, evaluations, and inspection services.

LEGISLATIVE BACKGROUND

On September 28, 1945, President Truman issued Proclamation 2667, upheld by the Supreme Court in 1947, which stated that "the Government of the United States regards the natural resources of the subsoil and seabed of the continental shelf beneath the high seas but contiguous to the coasts of the United States as appertaining to the United States, subject to its jurisdiction and control." Although the oil industry had been moving offshore for nearly half a century, this proclamation essentially arrested further development.

The Submerged Lands Act of May 22, 1953 (67 Stat. 29; 43 U.S.C. 1301-1315) returned to all the coastal States a belt of submerged lands seaward of their coastlines to a distance of 3 geographical miles and extended to each the opportunity to prove entitlement in judicial proceedings to a greater grant up to 3 marine leagues (9 geographical miles) through proof that it had in its charter a boundary extending more than 3 miles from its coast when it came into the Union, or such an extended boundary had been approved by Congress prior to enactment of the Submerged Lands Act. The act preserved Federal ownership and control of the subsoil and seabed of the submerged lands lying seaward of the belt granted the coastal States.

The Outer Continental Shelf Lands Act of August 7, 1953 (67 Stat. 462; 43 U.S.C. 1331-1343) reaffirmed that those lands beyond the 3 geographical mile limit, or more, appertain to and are subject to the jurisdiction, control, and power of disposition of the Federal Government, and authorized the Secretary of the Interior to grant mineral leases to Outer Continental Shelf lands and to prescribe such regulations as might be necessary to carry out the provisions of the act. With respect to oil, gas, sulfur, and other mineral operations on the Outer Continental Shelf, the Secretary has promulgated the regulations contained in Part 250 of Title 30 of the Code of Federal Regulations. These regulations are implemented and enforced by the U.S. Geological Survey.

OUTER CONTINENTAL SHELF

The legal and physiographic definitions of continental shelf are not the same. Legally, the Outer Continental Shelf comprises that part of the continental margin adjacent to the United States which remained subject to Federal jurisdiction and control after enactment of the Submerged Lands Act. The 1958 Geneva Convention on the Continental Shelf, which the United States ratified in 1961, defines the seaward limit of the continental shelf as out "to a depth of 200 meters or, beyond that limit, to where the depth of the superadjacent waters admits to the exploitation of the natural resources of the said areas * * * ." However, this definition of seaward limits is not precise, nor has a precise definition been developed at subsequent conventions on the law of the sea. Under the provisions of the Outer Continental Shelf Lands Act, the subsoil and the seabed underlying these ocean waters belong to the United States and are subject to its jurisdiction and control. The act specifically excludes the high seas of the waters above the Outer Continental Shelf particularly with respect to the rights to navigation and fishing. Because the seabed, subsoil, and any resource they may contain belong solely to the United States, they become a property of all citizens of the United States and must be administered for the mutual benefit of all. The Submerged Lands Act and the Outer Continental Shelf Lands Act established an equitable division of the ownership and jurisdiction of the mineral resources of the continental shelf between the coastal States and the Federal Government. However, exploitation of the resources must be conducted in a manner that will result in a minimum of disruption to the waters overlying the Outer Continental Shelf, the navigable waters within the seaward boundary of the adjacent State, and the public and private property located on the adjoining mainland (Adams, 1972).

HISTORICAL BACKGROUND

The earliest offshore oil production in the United States was developed off Summerland, Calif., in 1896. The offshore portion of the field was an extension of an onshore discovery that had been made prior to 1894. The offshore wells were drilled from wooden piers extending out from the shoreline. In all, more than 400 shallow wells were drilled and completed at a depth of about 600 feet. At that time, the State of California had no authority to lease tidelands areas, so these wells were drilled under leases obtained from the littoral landowners (Adams, 1972).

The discovery of the Creole field in 1938 in the Gulf of Mexico, 1½ miles from shore in 26 feet of water, marked the petroleum industry's first successful venture into open, unprotected waters. In November 1947, a discovery was made in Ship Shoal Block 32 off the Louisiana coast, 12 miles from shore in water 16 feet deep. This well was the first offshore well to be drilled out of sight of land. It was also the first offshore well drilled from a mobile platform, thus initiating the technology that has subsequently been utilized to drill more than 18,000 offshore oil and gas wells in the waters of the United States. Of these, more than 11,000 have been drilled in Outer Continental Shelf waters (Offshore, 1974).

From this beginning, technology has advanced to the stage that production platforms have been installed in the Gulf of Mexico in water depths up to 373 feet. In the Santa Barbara Channel off California, seven exploratory wells have been drilled in water more than 1,200 feet deep. One of these wells, currently a water-depth record in the United States,

was successfully drilled in 1,497 feet of water to a total depth of 10,453 feet (Adams, 1972). For the same area of the Santa Barbara Channel, a fixed drilling and production platform, 940 feet tall to be placed in 850 feet of water, is under construction (U.S. Geol. Survey, 1974a).

STATISTICAL BACKGROUND

LEASE SALES

Under the provisions of the Outer Continental Shelf Lands Act, the Secretary of the Interior "is authorized to grant to the highest responsible qualified bidder by competitive bidding under regulations promulgated in advance, oil and gas leases on submerged lands of the Outer Continental Shelf * * *." Additionally, the Secretary is authorized to issue leases on the Outer Continental Shelf for sulfur and "to grant * * * leases of any mineral other than oil, gas, and sulfur in any area of the Outer Continental Shelf not then under lease for such mineral * * *."

Three lease sales in 1954 resulted in the issuance of 114 leases (109 for oil and gas and 5 for sulfur) which covered 486,870 acres and brought a total bonus of $140,969,005 and a first-year rental of $1,435,625 for areas off the coast of Texas and Louisiana. By 1973, two lease sales resulted in the granting of 187 oil and gas leases covering 1,032,570 acres and bringing a total bonus of $3,082,462,611 and a first year rental of $3,097,716 for areas off the coasts of Texas, Mississippi, Louisiana, Alabama, and Florida.

During the 20-year period from 1954 through 1973, there have been a total of 33 lease sales off the coasts of Alabama, California, Florida, Louisiana, Mississippi, Oregon, Texas, and Washington. Three sales for sulfur leases resulted in the granting of 59 leases covering 102,625 acres for a total bonus of $35,688,959 and a first-year rental of $282,875. Two sales of salt leases brought a bonus of $105,814 and a first-year rental of $14,985 for two leases covering 4,995 acres. The remaining 28 sales were for oil and gas leases. A total of 1,966 oil and gas leases covering 9,012,345 acres were granted for a total bonus of $9,770,196,127 and a first-year rental of $29,651,320. Overall, 2,027 leases comprising 9,119,965 acres have been granted, resulting in a total bonus of $9,805,990,900 and a first-year rental of $29,949,180 (tables 1 and 2).

As of December 31, 1973, the total number of leases under supervision, including salt and sulfur, was 1,266 covering 5,613,983 acres. Of this total, 726 leases were producing or producible and 540 were non-producing. The non-producing leases are still in an exploratory stage where commercial produc-

TABLE 1.—*Outer Continental Shelf lease sales by years, states, minerals*

[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

Date of sale	Adjacent state	Mineral	No. of leases	Acreage	Bonus	First year rental
10-13-54	Louisiana	Oil & Gas	90	394,721	$116,378,476	$ 1,184,175
10-13-54	Louisiana	Sulfur	5	25,000	1,233,500	50,000
11-9-54	Texas	Oil & Gas	19	67,149	23,357,029	201,450
Total 1954			114	486,870	140,969,005	1,435,625
7-12-55	Louisiana	Oil & Gas	94	252,807	100,091,263	758,442
7-11-55	Texas	Oil & Gas	27	149,760	8,437,462	449,280
Total 1955			121	402,567	108,528,725	1,207,722
5-26-59	Florida	Oil & Gas	23	132,480	1,711,872	397,440
8-11-59	Louisiana	Oil & Gas	19	38,820	88,035,121	388,200
Total 1959			42	171,300	89,746,993	785,640
2-26-60	Louisiana	Oil & Gas	99	464,046	246,909,784	1,392,159
2-26-60	Texas	Oil & Gas	48	240,480	35,732,031	721,440
5-19-60	Louisiana	Salt	1	2,500	75,250	7,500
Total 1960			148	707,026	282,717,065	2,121,099
12-15-61	California	Phosphate	6	30,240	122,000	15,120
5-12-65	Refunded		(6)	(30,240)	(122,000)	(15,120)
3-13-62	Louisiana	Oil & Gas	206	951,811	177,260,305	2,855,433
3-16-62	Texas	Oil & Gas	10	28,800	557,720	86,400
	Louisiana	Oil & Gas	195	927,746	267,775,727	2,783,238
10-9-62	Louisiana	Oil & Gas	9	16,178	43,887,359	161,780
Total 1962			420	1,924,535	489,481,111	5,886,851
5-14-63	California	Oil & Gas	57	312,945	12,807,587	938,838
4-28-64	Louisiana	Oil & Gas	23	32,673	60,340,626	326,780
10-1-64	Oregon	Oil & Gas	74	425,433	27,768,772	1,276,302
10-1-64	Washington	Oil & Gas	27	155,420	7,764,928	466,260
Total 1964			124	613,526	95,874,326	2,069,342
12-14-65	Texas	Sulfur	50	72,000	33,740,309	216,000
3-29-66	Louisiana	Oil & Gas	17	35,056	88,845,963	350,570
10-18-66	Louisiana	Oil & Gas	24	104,717	99,164,930	523,600
12-15-66	California	Oil & Gas	1	1,995	21,189,000	9,980
Total 1966			42	141,768	209,199,893	884,150
6-13-67	Louisiana	Oil & Gas	158	744,456	510,079,178	2,233,458
9-5-67	Louisiana	Salt	1	2,495	30,564	7,485
Total 1967			159	746,951	510,109,742	2,240,943
2-6-68	California	Oil & Gas	71	363,181	602,719,262	1,089,543
5-21-68	Texas	Oil & Gas	110	541,304	593,899,046	1,623,915
11-19-68	Louisiana	Oil & Gas	16	29,682	149,868,789	296,820
Total 1968			197	934,167	1,346,487,097	3,010,278
1-14-69	Louisiana	Oil & Gas	20	48,505	44,037,339	485,050
5-13-69	Louisiana	Sulfur	4	5,625	715,150	16,875
12-16-69	Louisiana	Oil & Gas	16	60,153	66,908,196	601,550
Total 1969			40	114,283	111,660,685	1,103,475
7-21-70	Louisiana	Oil & Gas	19	44,642	97,769,013	446,420
12-15-70	Louisiana	Oil & Gas	118	551,398	846,784,660	1,654,194
Total 1970			137	596,040	944,553,673	2,100,614
11-4-71	Louisiana	Oil & Gas	11	37,222	96,304,522	372,230
9-12-72	Louisiana	Oil & Gas	62	290,321	585,827,925	870,996
12-19-72	Louisiana	Oil & Gas	116	535,874	1,665,519,631	1,607,661
Total 1972			178	826,195	2,251,347,556	2,478,657
6-19-73	Louisiana	Oil & Gas	4	20,000	53,901,709	60,000
6-19-73	Texas	Oil & Gas	96	527,173	1,537,495,671	1,581,519
12-20-73	Alabama	Oil & Gas	13	74,106	135,834,100	222,318
12-20-73	Florida	Oil & Gas	62	357,120	1,100,399,131	1,071,360
12-20-73	Louisiana	Oil & Gas	6	19,611	139,130,000	58,839
12-20-73	Mississippi	Oil & Gas	6	34,560	115,702,000	103,680
Total 1973			187	1,032,570	3,082,462,611	3,097,716
Grand Total			2,027	9,119,965	$9,805,990,900	$29,949,180

tion has not been discovered (tables 3 and 4).

PRODUCTION AND ROYALTY VALUE

All oil and gas leases on the Outer Continental Shelf issued through 1973 have required a royalty rate of 16⅔ percent in the amount or value of production from the Lease. The annual rental or minimum royalty required for leases in unproven areas has been $3 per acre. In the cases of leases in proven areas, the annual rental or minimum royalty has generally been $10 per acre. Although the dollar amount of rental or minimum royalty is the same, rental is paid at the beginning of the lease year on lands that have not been proven producible; whereas minimum royalty is paid at the end of the lease year on lands that have been determined by the Geological Survey to be capable of producing oil or gas in paying quantities.

The production value of all products from the Outer Continental Shelf in 1953 was $5,036,861. Of this amount the total revenue to the Federal Treasury was $2,358,172. In 1954, total revenue from Outer Continental Shelf lands was $147,660,265 and the production value was $14,370,098. By 1973, the production value of all products from Outer Continental Shelf lands was $2,486,864,855 and the total revenue to the Federal Treasury was $3,494,981,440 (tables 5 and 6).

Cumulative data through 1973 indicate the total production value of all products from Outer Continental Shelf lands is $15,729,172,944 and total revenue is $12,577,602,478. *The total revenue to the United States Treasury through 1973 has amounted to 80 percent of the total production value of all products from Outer Continental Shelf lands.*

TABLE 2.—*Summary of Outer Continental Shelf lease sales, October 13, 1954 through December 20, 1973, by state and mineral*

[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

Lease sales		No. of leases	Acreage	Bonus	First year rental
By state	By mineral				
Alabama		13	74,106	$ 135,834,100	$ 222,318
California		129	678,121	636,715,849	2,038,361
Florida		85	489,600	1,102,111,003	1,468,800
Louisiana		1,333	5,636,059	5,546,874,980	19,493,455
Mississippi		6	34,560	115,702,000	103,680
Oregon		74	425,433	27,768,772	1,276,302
Texas		360	1,626,666	2,233,219,268	4,880,004
Washington		27	155,420	7,764,928	466,260
Total		2,027	9,119,965	$9,805,990,900	$29,949,180
	Oil and gas	1,966	9,012,345	$9,770,196,127	$29,651,320
	Salt	2	4,995	105,814	14,985
	Sulfur	59	102,625	35,688,959	282,875
	Total	2,027	9,119,965	$9,805,990,900	$29,949,180

TABLE 3.—*Outer Continental Shelf producing and non-producing leases (oil, gas, salt, and sulfur) under supervision, by years, as of December 31*

[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

	Producing leases		Non-producing leases		Total	
Year	Number	Acreage	Number	Acreage	Number	Acreage
1954	58	240,028	420	1,288,665	478	1,528,693
1955	106	438,076	505	1,938,656	611	2,376,732
1956	171	674,176	391	1,181,162	562	1,855,338
1957	213	775,566	208	709,941	421	1,485,507
1958	230	969,575	162	551,377	392	1,520,952
1959	272	1,102,660	117	384,446	389	1,487,106
1960	299	1,167,499	170	823,321	469	1,990,820
1961	315	1,228,839	148	705,367	463	1,934,206
1962	332	1,300,955	526	2,424,225	858	3,725,180
1963	363	1,431,827	524	2,458,188	887	3,890,015
1964	375	1,504,462	606	2,870,912	981	4,375,374
1965	425	1,679,617	512	2,450,253	937	4,129,870
1966	488	1,964,529	486	2,128,147	974	4,092,676
1967	525	2,086,074	358	1,519,663	883	3,605,737
1968	538	2,156,185	485	2,199,604	1,023	4,355,789
1969	568	2,308,538	453	2,004,712	1,021	4,313,250
1970	608	2,529,909	409	1,750,765	1,017	4,280,674
1971	649	2,709,997	434	1,892,294	1,083	4,602,291
1972	698	2,914,964	325	1,423,103	1,023	4,338,067
1973	726	3,039,418	540	2,574,565	1,266	5,613,983

LAND AND WATER CONSERVATION FUND

Revenue from the Outer Continental Shelf is a major source of funds for the Land and Water Conservation Fund. The fund is the largest Federal grant-in-aid program of assistance to states, counties, and cities for the acquisition and development of public parks, open space, and recreation lands and water (table 7). In addition, the fund pays acquisition costs for authorized areas being added to the national systems of parks, forests, wildlife refuges, wild and scenic rivers, and scenic and recreation trails.

TABLE 4.—*Outer Continental Shelf producing and non-producing leases (oil, gas, salt, and sulfur) under supervision as of December 31, 1973, by states and products*

[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

Adjacent state and product	Producing leases		Non-producing leases		Total	
	Number	Acreage	Number	Acreage	Number	Acreage
Alabama - Oil & Gas	--	--	13	74,106	13	74,106
California - Oil & Gas	17	82,576	52	269,301	69	351,877
Florida - Oil & Gas	--	--	62	357,120	62	357,120
Louisiana - Oil & Gas	660	2,769,934	309	1,306,336	969	4,076,270
Louisiana-Salt	2	4,995	--	--	2	4,995
Louisiana-Sulfur	5	6,953	1	1,875	6	8,828
Mississippi - Oil & Gas	--	--	6	34,560	6	34,560
Texas	42	174,960	97	531,267	139	706,227
Total	726	3,039,418	540	2,574,565	1,266	5,613,983

TABLE 5.—*Outer Continental Shelf revenue and production value, percentage cumulative revenue of cumulative production value, calendar years 1953–1973*

[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

Year	Bonuses	Minimum royalties	Rentals	Shut-in gas payments	Royalties	Total revenue	Total cumulative revenue	Total production value	Total cumulative production value	Per-cent 1/
All states										
1953	$ -	$ -	$ 1,359,630	$ 30,650	$ 967,892	$ 2,358,172	$ 2,358,172	$ 5,036,861	$ 5,036,861	47
1954	140,969,005	-	3,855,333	86,950	2,748,977	147,660,265	150,018,437	14,370,098	19,406,959	774
1955	108,528,725	-	3,406,351	122,000	5,140,006	117,197,082	267,215,519	27,060,679	46,467,638	575
1956	-	-	4,006,193	79,950	7,629,383	11,715,526	278,931,045	39,497,871	85,965,509	324
1957	-	68,581	3,270,122	110,268	11,391,245	14,840,216	293,771,261	61,072,588	147,038,097	200
1958	-	184,396	2,420,584	121,218	17,423,878	20,150,076	313,921,337	96,471,136	243,509,233	129
1959	89,746,993	171,036	2,285,725	84,984	26,539,977	118,828,715	432,750,052	150,472,527	393,981,760	110
1960	282,717,065	316,975	3,603,140	49,350	37,095,301	323,781,831	756,531,883	200,969,615	594,951,375	127
1961	-	314,121	3,073,861	37,100	47,920,332	51,345,414	807,877,297	273,636,456	868,587,831	93
1962	489,481,111	517,722	8,412,207	62,200	66,096,334	564,569,574	1,372,446,871	376,675,900	1,245,263,731	102
1963	12,807,587	668,339	8,435,184	52,950	76,999,225	98,963,285	1,471,410,156	450,866,484	1,696,130,215	87
1964	95,874,326	820,343	9,798,573	45,800	88,400,230	194,939,272	1,666,349,428	506,783,510	2,202,913,725	76
1965	33,740,309	1,072,699	8,731,378	38,450	102,862,540	146,445,376	1,812,794,804	594,222,732	2,797,136,457	65
1966	209,199,893	1,367,250	6,869,277	41,700	136,987,537	354,465,657	2,167,260,461	801,724,611	3,598,861,068	60
1967	510,109,742	1,891,515	6,208,936	41,400	157,607,609	675,859,202	2,843,119,663	947,214,691	4,546,075,759	63
1968	1,346,487,097	2,145,178	8,230,787	52,300	201,136,931	1,558,052,293	4,401,171,956	1,179,912,209	5,725,987,968	77
1969	111,660,685	1,923,632	8,312,607	41,650	240,090,666	362,029,240	4,763,201,196	1,443,870,472	7,169,858,440	66
1970	944,553,673	1,745,864	8,607,855	47,700	283,494,568	1,238,449,660	6,001,650,856	1,707,593,450	8,877,451,890	68
1971	96,304,522	1,891,000	7,741,997	32,300	350,042,488	456,012,307	6,457,663,163	2,135,677,078	11,013,128,968	59
1972	2,251,347,556	2,019,533	7,984,897	49,550	363,556,339	2,624,957,875	9,082,621,038	2,229,179,121	13,242,308,089	69
1973	3,082,462,611	2,391,249	8,948,816	52,650	401,126,114	3,494,981,440	12,577,602,478	2,486,864,855	15,729,172,944	80
Total	$9,805,990,900	$19,509,433	$125,563,453	$1,281,120	$2,625,257,572	$12,577,602,478	$12,577,602,478	$15,729,172,944	$15,729,172,944	80

1/ Percentage accumulated revenue of accumulated production value.

TABLE 6.—*Cumulative bonuses, minimum royalties, rentals, shut-in gas payments, and royalties Outer Continental Shelf, by states, August 7, 1954 to December 31, 1973*

[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

State	Bonuses	Minimum royalties	Rentals	Shut-in gas payments	Royalties	Total
Alabama	$ 135,834,100	$ --	$ 222,318	$ --	$ --	$ 136,056,418
California	636,715,849	201,695	8,883,564	--	58,561,372	704,362,480
Florida	1,102,111,003	--	2,453,760	--	--	1,104,564,763
Louisiana	5,546,874,980	18,210,623	94,457,835	1,281,120	2,529,875,983	8.190,700,541
Mississippi	115,702,000	--	103,680	--	--	115,805,680
Oregon	27,768,772	--	3,759,021	--	--	31,527,793
Texas	2,233,219,268	1,097,115	14,284,195	--	36,820,217	2,285,420,795
Washington	7,764,928	--	1,399,080	--	--	9,164,008
Total	$9,805,990,900	$19,509,433	$125,563,453	$1,281,120	$2,625,257,572	$12,577,602,478

TABLE 7.—*Land and Water Conservation Fund planning, acquisition, and development grants to states as of June 30, 1974*

States	Planning		Acquisition		Development		Total	
	Number	Amount	Number	Amount	Number	Amount	Number	Amount
Alabama	3	$ 127,605.51	58	$ 2,098,215.14	142	$ 13,232,893.12	203	$ 15,458,713.77
Alaska	3	305,973.94	37	3,455,751.50	91	5,843,799.19	131	9,605,524.63
Arizona	5	148,755.70	61	4,128,672.25	211	10,278,888.33	277	14,556,316.28
Arkansas	7	259,814.94	39	3,226,384.93	79	7,731,507.65	125	11,217,707.52
California	4	607,116.74	123	45,495,272.32	186	23,658,245.75	313	69,760,634.81
Colorado	3	36,264.82	101	5,197,283.85	344	8,304,067.57	448	13,537,616.24
Connecticut	3	60,446.63	110	13,212,170.66	8	2,068,597.12	121	15,341,214.41
Oelaware	2	83,498.56	52	5,632,597.30	6	2,718,060.00	60	8,434,155.86
Oistrict of Columbia	1	197,228.00	2	202,400.00	27	5,261,331.75	30	5,660,959.75
Florida			43	21,690,280.79	38	5,479,239.50	81	27,169,520.29
Georgia	5	401,571.18	69	5,499,308.67	158	13,807,011.51	232	19,707,891.36
Hawaii	3	205,782.88	17	3,755,336.41	54	5,350,118.03	74	9,311,237.32
Idaho	4	163,250.00	40	1,251,104.97	140	8,016,766.11	184	9,431,121.08
Illinois	3	57,603.63	169	37,848,729.20	29	2,454,429.09	201	40,360,761.92
Indiana	5	146,231.49	65	4,465,594.22	126	15,385,838.83	196	19,997,664.54
Iowa	4	73,022.61	180	6,348,288.54	305	7,018,413.31	489	13,439,724.46
Kansas	3	144,895.19	50	2,400,108.25	176	10,557,995.33	229	13,102,998.77
Kentucky	6	194,240.92	98	3,715,905.64	175	11,535,643.67	279	15,445,790.23
Louisiana	8	334,557.10	74	8,994,323.06	138	10,868,593.98	220	20,197,474.14
Maine	5	92,589.00	104	5,296,762.36	134	3,526,613.86	243	8,915,965.22
Maryland			88	15,826,237.29	168	5,849,241.07	256	21,675,478.36
Massachusetts	3	412,250.94	60	9,318,550.61	92	15,653,342.57	155	25,384,144.12
Michigan	2	273,979.26	197	13,106,742.00	325	19,459,819.51	524	32,840,540.77
Minnesota	6	340,736.97	261	9,264,418.29	330	7,185,937.88	597	16,791,093.14
Mississippi	5	227,470.64	28	1,239,833.39	104	10,243,096.39	137	11,710,400.42
Missouri	5	229,667.19	255	11,321,977.79	220	12,286,159.37	480	23,837,804.35
Montana	3	197,808.25	73	1,491,220.64	224	7,905,997.97	300	9,595,026.86
Nebraska	2	51,347.02	93	2,532,912.45	239	8,843,460.42	334	11,427,719.89
Nevada	4	207,866.52	12	6,856,210.57	49	3,888,625.69	65	10,952,702.78
New Hampshire	3	155,635.55	50	2,744,403.47	83	4,407,563.53	136	7,307,602.55
New Jersey	1	32,500.00	29	12,058,749.79	162	19,904,202.74	192	31,995,452.53
New Mexico	10	197,897.91	34	1,096,887.05	238	9,283,692.26	282	10,578,477.22
New York	5	567,895.36	75	12,369,647.63	190	50,347,781.70	270	63,285,324.69
North Carolina	5	323,271.68	116	7,254,571.78	195	10,415,482.25	316	17,993,325.71
North Oakota	4	45,919.80	84	717,024.06	417	8,502,626.88	505	9,265,570.74
Ohio	3	385,850.00	157	21,006,913.22	153	19,220,865.95	313	40,613,629.17
Oklahoma	5	275,944.57	51	2,126,720.20	231	10,464,769.11	287	12,867,433.88
Oregon	3	371,583.28	147	12,965,828.89	393	4,341,954.87	543	17,679,367.04
Pennsylvania	3	554,858.25	37	4,554,119.58	258	42,400,398.29	298	47,509,376.12
Rhode Island	2	255,963.07	53	2,879,720.58	62	5,104,823.25	117	8,240,506.90
South Carolina	7	365,596.95	72	1,259,314.11	288	10,005,601.05	367	11,630,512.11
South Oakota	4	24,732.46	74	1,344,529.80	317	9,625,259.11	395	10,994,521.37
Tennessee	3	206,164.07	64	6,716,611.87	120	11,037,564.08	187	17,960,340.02
Texas	2	1,074,581.98	94	8,664,590.62	245	32,048,165.29	341	41,787,337.89
Utah	4	139,228.76	53	3,981,612.04	102	7,956,586.98	159	12,077,427.78
Vermont	3	96,787.57	81	4,587,137.60	100	3,554,628.30	184	8,238,553.47
Virginia	1	46,138.14	49	14,454,205.08	64	7,334,792.98	114	21,835,136.20
Washington	3	225,796.85	103	8,848,413.73	98	7,493,326.78	204	16,567,537.36
West Virginia	2	61,941.22	52	1,198,389.61	104	10,888,859.18	158	12,149,190.01
Wisconsin	2	39,397.37	416	11,568,696.12	382	8,534,743.73	800	20,142,837.22
Wyoming	6	348,371.35	34	343,216.09	317	8,011,955.46	357	8,703,542.90
American Samoa			1		15	567,828.43	16	567,828.43
Guam	2	34,100.00	2	15,000.00	9	701,830.50	13	750,930.50
Puerto Rico	2	125,000.00	9	358,320.00	20	6,101,139.76	31	6,584,459.76
Virgin Islands	2	92,400.00	7	253,740.25	3	321,210.87	12	667,351.12
Total	194	11,629,131.82	4,503	398,240,956.26	8,884	572,991,387.90	13,581	982,861,475.98

The fund, which is administered by the Bureau of Outdoor Recreation in the Department of the Interior, was established by Congress in 1964 (Pub. L. 88-578, Sept. 3, 1964, 78 Stat. 897). Amendments to the original legislation provided that the annual income of the fund be not less than $200,000,000 for the fiscal years of 1968, 1969, and 1970 and $300,000,000 for the fiscal years of 1971 through 1989 (Pub. L. 89-72, July 9, 1965, 79 Stat. 218; Pub. L. 90-401, July 15, 1968, 82 Stat. 354; Pub. L. 91-308, July 7, 1970, 84 Stat. 410; and Pub. L. 91-485, Oct. 22, 1970, 84 Stat. 1084). These amendments also provided that, to the extent other appropriations are not sufficient to make the total annual income of the fund amount to these levels, an amount sufficient to cover the remainder would be credited to the fund from revenues due and payable to the United States for deposit in the Treasury as miscellaneous receipts under the Outer Continental Shelf Lands Act.

For the 6 fiscal years from 1969 through 1974, the total statutory funding of the Land and Water Conservation Fund has amounted to 1.6 billion dollars. Of this amount, receipts under the Outer Continental Shelf Lands Act have provided 1.1 billion dollars or 71 percent of the total funding (table 8).

The total receipts from the Outer Continental Shelf during this period have amounted to 12.5 billion dollars, of which 10.2 billion dollars was in net bonuses and rents, 1.3 billion dollars was in royalties, and 1.0 billion dollars was held in escrow funds (table 9).

The 1.1 billion dollars allocated to the Land and Water Conservation Fund has amounted to 11.1 percent of the net bonuses and rents, 86.9 percent of the royalties (fig. 1), or 9.1 percent of the total revenue from the Outer Continental Shelf.

LEASING PROCEDURE FOR THE OUTER CONTINENTAL SHELF

The initial step in the leasing process, which is primarily the responsibility of the Bureau of Land Management with technical assistance from Geological Survey, is the selection of general areas for inclusion in a schedule. Factors underlying this selection include initial assessments of oil and gas potential as estimated by both industry and Government, environmental resources that might be affected by Outer Continental Shelf development, alternative energy sources, the availability of technology, and the proximity to markets. These are

TABLE 8.—*Funding of the Land and Water Conservation Fund by Outer Continental Shelf receipts, fiscal years 1969 to 1974*

Fiscal years	Statutory funding level	Funding from OCS receipts	
		Amount	Percent
1969	$ 200,000,000	$ 126,873,300.34	63.4
1970	200,000,000	107,882,204.45	53.9
1971	300,000,000	210,092,090.91	70.0
1972	300,000,000	223,677,068.29	74.6
1973	300,000,000	223,983,125.92	74.7
1974	300,000,000	243,889,917.71	81.3
Total	$1,600,000,000	$1,136,397,707.62	71.0

TABLE 9.—*Outer Continental Shelf receipts, fiscal years 1969 to 1974*

Fiscal year	Bonuses and rents	Royalties	Escrow	Total
1969	$ 350,194,610.43	$ 78,083,889.47	$ 285,633,591.67	$ 713,912,091.57
1970	73,280,497.60	113,580,953.89	146,947,619.87	333,809,071.36
1971	890,634,479.13	159,914,891.13	221,707,956.30	1,272,257,326.56
1972	28,029,741.58	251,323,014.27	183,327,304.02	462,680,059.87
1973	1/ 2,928,891,918.88	1/ 1,026,685,097.63	1/ (1,017,163,160.24)	2,938,413,856.27
1974	6,340,292,958.91	408,101,161.00	66,311,861.88	6,814,705,981.79
Sub-total	$ 10,611,324,206.53	$ 2,037,689,007.39	$ (113,234,826.50)	$ 12,535,778,387.42
	393,184,441.83	1/ 730,151,695.29	1/ 1,123,336,137.12	-0-
Total	$ 10,218,139,764.70	$ 1,307,537,312.10	$ 1,010,101,310.62	$ 12,535,778,387.42

1/ On July 31, 1972, $1,123,336,137.12 was transferred from escrow to general fund accounts. $393,184,441.83 was transferred to bonuses and rents and $730,151,695.29 was transferred to royalties.

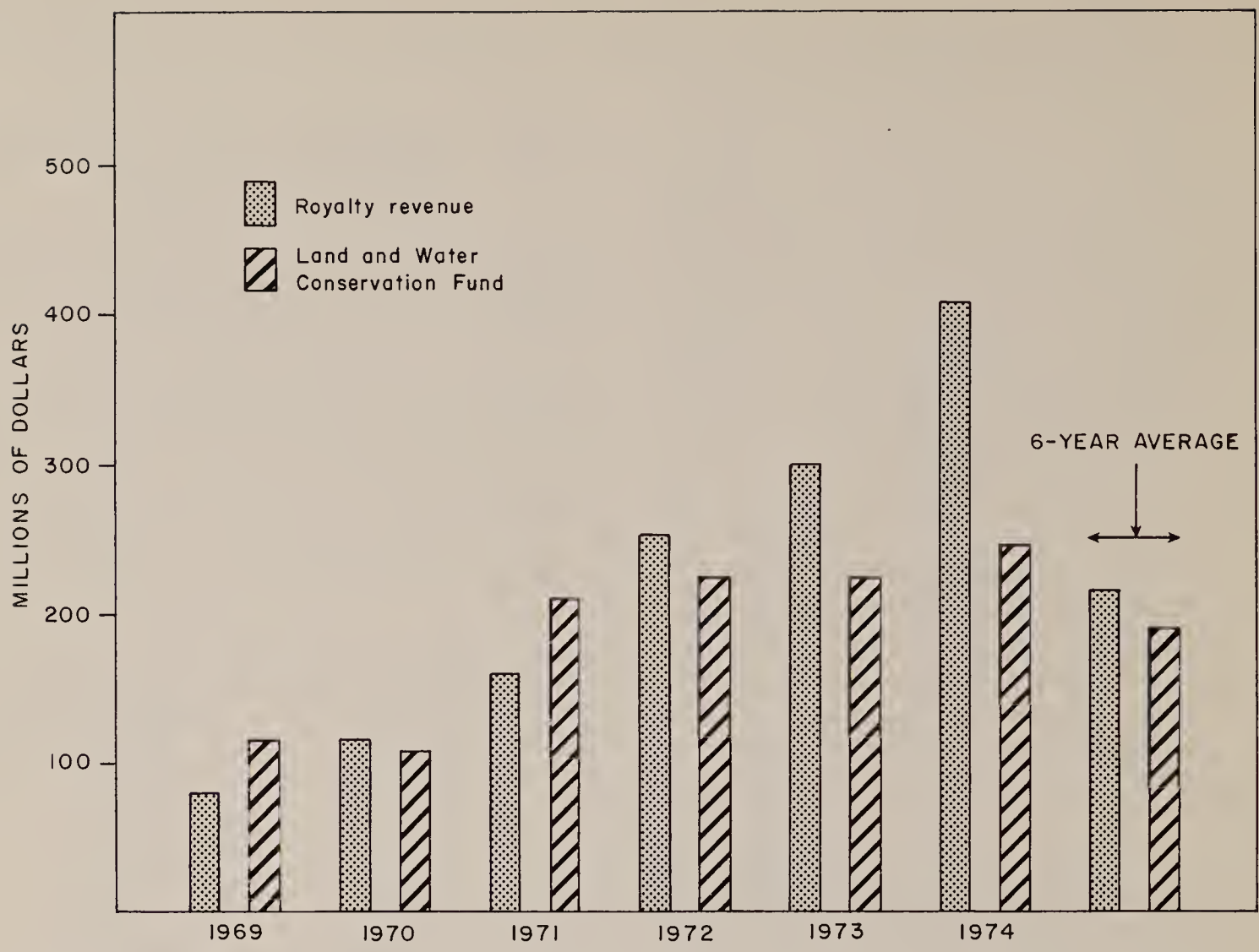

FIGURE 1.—Outer Continental Shelf royalty revenue and funding of the Land and Water Conservation Fund, by fiscal years 1969 to 1974.

weighed and balanced in developing a schedule of proposed lease sales which will result in the most expeditious discovery and production of oil and gas. Once an area is scheduled for a possible sale, several activities occur: (1) an acceleration of industry's collection of geological and geophysical data under permits issued by the Geological Survey, (2) Department of the Interior baseline data studies, (3) the sequential steps of the sale process, and (4) detailed resource evaluation of each tract by the Geological Survey.

LEASING SCHEDULE

A leasing schedule is the framework used to determine the timing and initiation of individual sale procedures. It is continually being updated and revised within the Department of the Interior. Improved resource information has been acquired and the overall supporting analysis is being refined in line with the current energy situation. In the development of the schedule, the Department of the Interior considers its three leasing objectives of orderly resource development, protection of the environment, and receipt of fair market value. These objectives constitute overall policy guidelines for the Outer Continental Shelf leasing program and consideration accorded to each may vary from one component to another.

Various options are reviewed from the perspective of receipt of fair market value. The size and frequency of sales can induce or inhibit a competitive market which affects the Government's receipt of fair market value. Full consideration of all objectives results in the development of a leasing schedule. However, as stated earlier, this schedule is tentative and is continually subjected to review, updating, and revision.

COLLECTION OF GEOLOGICAL AND GEOPHYSICAL DATA

Most of the information used by both the Government and industry on the oil and gas potential of various Outer Continental Shelf areas is acquired by geological and geophysical surveys. A considerable amount of these data are collected, under permits

issued by the Geological Survey, by specialized data collection firms which sell or furnish the information to oil companies and the Department of the Interior.

GEOLOGICAL ACTIVITY

Geological exploration of the Outer Continental Shelf consists of bottom sampling, shallow coring, and deep stratigraphic testing. Usually, a program of bottom sampling and shallow coring is conducted simultaneously using a small marine drilling vessel. Bottom samples are obtained by dropping a weighted tube to the ocean floor and recovering it with an attached wire line. Penetration is normally limited to a few feet depending upon the nature of the ocean floor. The sample obtained is useful in identifying the type and origin of the formation. If the formation is sedimentary, the geologic age can be determined by identification of fossils.

Shallow coring is performed by conventional rotary drilling equipment. Choice of location is carefully controlled to avoid any hazards that might cause environmental harm. Penetration is limited usually to the recovery of several feet of consolidated rock. Geological examination of the cores provides useful information on the general geology of an area.

A deep stratigraphic test is drilled for the acquisition of geoscientific information and may go as deep as 16,000 feet. Stipulations require that the test be drilled on an off-structure location, that no testing will be permitted, and that data will be released within 60 days following the first lease sale in the area. By electrical logging of the hole and examination of drill cuttings and cores, the complete geological section can be determined.

GEOPHYSICAL ACTIVITY

Geophysical exploration by measuring the velocity of shock, or seismic waves through various rock formations provides additional information at all depths. The shallow information is of value in identifying potentially hazardous conditions such as surface faulting, potential slide areas, or shallow gas pockets. This type of information is valuable in the choice and approval of drilling and platform locations.

Deep-penetration seismic information is used for regional and detailed mapping. Geophysicists interpret these data by mapping two or more seismic reflections corresponding to the depths of expected hydrocarbon production. These maps show the types of structures such as salt domes, folds, or faults that are most likely to be encountered in the area.

These geological and geophysical data are used by industry in nominating tracts for lease and preparing bids for lease sales. The Geological Survey uses the information for general sale area identification, tract selection, resource evaluation, and lease management.

ENVIRONMENTAL BASELINE DATA STUDIES

Baseline studies are conducted in frontier areas to establish an environmental benchmark against which future measurements, taken during the monitoring phase, can be compared for the purpose of detecting possible adverse effects resulting from exploration and development activities. These studies are designed after thorough assessment of published and unpublished data, on-going research, and planned research. Each study is designed with scientific input that is acquired in part through environmental symposiums held near the area to be studied. The study design is further reviewed by the Outer Continental Shelf Research Management Advisory Board. This Board was established in March 1974 to provide advice to the Department concerning design and implementation of environmental development on the Outer Continental Shelf. The Board consists of a chairman, appointed by the Assistant Secretary for Land and Water Resources, representatives of Environmental Protection Agency, National Oceanic and Atmospheric Administration, Geological Survey and the Fish and Wildlife Service, in addition to representatives of the Governors of the 21 Coastal States.

Studies cover a wide range of disciplines including geology, geophysics, biology, physical oceanography, meteorology, and trace metal and hydrocarbon chemistry. These studies, conducted by contract with universities, National Oceanic and Atmospheric Administration, and the Geological Survey, include generation of original data as well as analysis of existing information.

Results of these efforts will be used by the Department in making management decisions regarding the development of marine mineral resources. Where available, the results will be used in tract selection, environmental impact analyses, formulation of lease stipulations, and modification of Outer Continental Shelf operating orders or leasing and operating regulations.

Environmental monitoring begins after the baseline study is complete and after a sale is held, to determine if petroleum exploration or production activities are affecting the environment. If adverse changes are detected, additional stipulations will be

added to leases, or changes would be made in the Outer Continental Shelf operating orders to mitigate or eliminate these adverse effects.

RESOURCE REPORTS

When an area is being considered for leasing, the Director of the Bureau of Land Management requests the U.S. Geological Survey to make a pre-nomination summary report on the geology and potential mineral resources of the area. In addition to the geologic report, resource reports as to possible effects of leasing on the total environment are requested from other Federal bureaus and departments with appropriate expertise such as the Fish and Wildlife Service, National Park Service, Bureau of Outdoor Recreation, Bureau of Mines, Bureau of Indian Affairs, Forest Service, National Oceanic and Atmospheric Administration, Environmental Protection Agency, Coast Guard, National Aeronautics and Space Administration, Federal Power Commission, Departments of Defense and Treasury, and the Federal Energy Administration. Resource reports are also requested from the adjacent State through the office of the governor. These reports are usually made at least 30 days prior to a call for nominations.

CALL FOR NOMINATIONS

The call for nominations is an official notice to the public and the oil and gas industry, published in the *Federal Register* and disseminated by a news release, to obtain an indication of interest in individual offshore tracts which may subsequently be offered for lease. Calls are issued for large contiguous areas usually embracing several million acres offshore a single state. The call for nominations also serves as an additional source of information by requesting comments on the proposal from any interested person or agency—State and local governments, environmental and conservation groups, academic and research institutions, business and professional groups, community organizations, and individuals. In addition to stating which tracts in an area should be studied for possible leasing because of their oil and gas potential, all respondents are requested to provide environmental, economic, and technical information on why specific tracts within an area should be excluded from the leasing process because of significant environmental consideration or other resource conflicts, such as fishing or recreation.

TRACT SELECTION

The Bureau of Land Management and Geological Survey use the nominations of industry, the resource and environmental information received from other Federal, State, and local agencies, information received from the public, as well as their own resource, environmental, technological, and economic information to select tracts for further analysis in the environmental impact statement.

Selection of tracts is made on the basis of need to develop prospective geologic structures and trends, to protect tracts in imminent danger of drainage, and to choose tracts most prospective for production. Certain tracts may be deleted at this stage because of overriding environmental considerations.

The list of selected tracts is published in the *Federal Register* as well as being disseminated in a news release prior to the availability of the draft environmental statement.

ENVIRONMENTAL IMPACT STATEMENT

DRAFT STATEMENT

The draft statement is prepared by the Bureau of Land Management as the lead agency with scientific assistance from the Geological Survey. During preparation, numerous contacts are made at the field level with the academic community, private research groups, environmental organizations, and State and local officials. These contacts are essential in order to help insure a maximum understanding of the environmental and economic concerns and to help gain an understanding of how the local citizenry perceives the issues involved.

The draft statement includes, among other things, a description of the lease proposal, a description of the marine and nearby onshore environment, a detailed analysis on a tract-by-tract basis of any possible adverse impacts on the environment, mitigating measures included in the proposal to reduce the possibility of adverse impacts, alternatives to the proposal, and the consultation and coordination with others in preparation of the statement. It also covers the technology necessary for exploration, development, and production from the proposed sale, as well as possible onshore socio-economic impacts.

Pertinent published and unpublished reports and resource evaluations are reviewed in preparation of the draft environmental statement. When ready, it is submitted to the Council on Environmental Quality and made available to the public for consideration. A notice of its availability is published in the *Federal Register* and the news media are informed by a news release.

PUBLIC HEARING

At least 30 days after publication of the draft environmental statement, a public hearing is held at a city in the vicinity of the proposed sale. A notice of the public hearing is published in the *Federal Register* and a news release is issued. Environmental organizations, the academic community, government representatives, industry, and the general public are invited to testify orally or in writing on the draft environmental statement in order to obtain the widest spectrum of views and information possible. All comments submitted for the public hearing are then considered in preparation of the final environmental statement.

FINAL STATEMENT

The comments and contributions of data received through the public hearings and the official review process are studied, along with any other late-arising information, and incorporated into the final environmental statement. The environmental statements are unbiased reporting documents which provide a basis for deciding whether or not to hold a sale, to delete particular tracts, or to place restrictions on specific tracts. The final statement is submitted to the Council on Environmental Quality and made available to the public. Notice of its availability is published in the *Federal Register* and disseminated to the news media by a news release.

DECISION BY THE SECRETARY

At least 30 days after the submission of the final environmental statement to the Council on Environmental Quality, the Secretary of the Interior decides whether the proposed sale will be held. The Secretary considers all environmental, resource, economic, and technical information available in the draft statement, public hearing, and final statement, as well as other pertinent information in order to weigh all factors related to his decision.

If the decision is that a sale will be held, determinations are made concerning which tracts will be offered and what the lease terms will be. The lease terms may be tailored to special requirements for any tract, and any tract may be withdrawn at any stage of this procedure on the basis of late-arising environmental data.

NOTICE OF SALE

If a decision is made to hold a sale, a notice is published in the *Federal Register* giving at least 30 days advance notice of the date, place, and time that bids are to be opened, the tracts to be included in the sale, the terms under which the sale will be held, and any special stipulations that may be imposed on particular tracts.

DETAILED RESOURCE EVALUATION OF EACH TRACT

Following the announcement of tracts and during the preparation and review of the environmental statements, the Geological Survey geologists, geophysicists, and petroleum engineers prepare detailed estimates of the value of the oil and gas on each tract that is being considered for sale. These estimates are based upon geophysical and geological data acquired by industry under permit and by the Department itself, geological data the Department has if other wells have been drilled in the area or other geological studies, engineering data relative to the facilities and costs of discovering and producing the oil and gas, and factors considering the probability that oil and gas actually exists on a specific tract. These estimates are delivered to the Bureau of Land Management immediately after the sale for use in determining whether a lease shall be issued.

LEASE SALE

Typically, leases are sold on the basis of a cash bonus bid with a one-sixth fixed royalty. The manager of the appropriate Bureau of Land Management office conducts the sale, publicly opening and reading all sealed bids. After the public reading, the bids are checked for technical and legal adequacy and sufficient bonus, 20 percent of which must accompany the bid. The Government reserves the right to reject any or all bids. Acceptance or rejection of bids is not made until after the post-sale evaluation.

DECISION TO ACCEPT OR REJECT BIDS

Whether individual leases shall be issued is based on an analysis of elements related to the Department of the Interior's stated goals of orderly and timely resource development, environmental protection, and receipt of fair market value. Protection of the environment is considered in advance of a sale and each tract is discussed in the environmental impact statement. The decision to award a lease to the highest bidder is made only after the Department has evaluated that bid in terms of its own information concerning the tract's value. As discussed earlier, the Geological Survey spends the four to six months prior to a sale preparing detailed estimates of the value of oil and gas on each tract. These estimates, coupled with indicators of competition expressed at

the sale, are used by the Department in determining if fair market value has been received.

ISSUANCE OF LEASE

For each lease where the bid is found acceptable and the decision to lease is made, the Bureau of Land Management issues a lease to the successful bidder. Upon issuance of the lease, the remaining 80 percent of the bonus bid and the first year's rental are due. Once the lease is issued, collection of rents and royalties and supervision of lease operations become the responsibility of the Geological Survey.

COORDINATION WITH STATE AND FEDERAL AGENCIES

Throughout the leasing process, the Department has continued liaison with the National Oceanographic and Atmospheric Administration, Army Corps of Engineers, the Coast Guard, Environmental Protection Agency, and all other Government agencies that play a role in managing the Outer Continental Shelf. The Department also seeks liaison with the appropriate coastal State agencies that play an active role in their State's coastal lands. The concern for sound coastal zone management and liaison with these other Federal agencies does not stop with the issuance of a lease but continues through the exploration and production phases. If oil and gas are found, pipeline permits are issued by the Department of the Interior, but only after all safety precautions are met. A pipeline management planning system will be implemented in all frontier areas to minimize both onshore and offshore impacts. Pipeline routing on the Outer Continental Shelf is determined after consultation with State officials who have authority over pipeline rights-of-way in State waters and onshore. Special provisions are made to minimize hazards such as fishing nets becoming snagged on pipelines. In addition, the Department willingly assists coastal States who request information for use in their assessment of the onshore environmental and economic impact of potential oil and gas development offshore.

As earlier noted, each pipeline laid on the Outer Continental Shelf requires a permit which may be subject to stipulations for safety and environmental protection. Among these stipulations is a requirement that all pipelines in less than 200-foot water depth be buried to a depth of at least 3 feet and all valves and taps be buried regardless of depth. Close attention is given to bottom stability, tides, and currents. Each permit application is subjected to an environmental assessment.

Shore-bound pipelines require permits from both the Federal Government and the adjacent State. Department of the Interior personnel work closely with State authorities to assure that the requirements of each are fully met and to select safe routes that will result in the minimum environmental damage and the least adverse onshore impact. It is only when oil or gas are found in commercial quantities that it is possible to fully analyze the impact and to develop plans for the routing of the pipeline and the associated onshore activity.

RESOURCE EVALUATION

In 1967, the Geological Survey established a mineral-resource evaluation program to develop improved methods of selecting and evaluating Outer Continental Shelf tracts proposed for leasing. Since establishing the program, the Geological Survey has expanded its geophysical, geological, and engineering capability to map, select, and evaluate the resource potential of the Outer Continental Shelf.

The primary responsibility of the resource evaluation and analysis program is to investigate the mineral potential of the Outer Continental Shelf, predominantly for oil and gas, sodium (salt), and sulfur. Data have been obtained and developed in all offshore areas of the contiguous United States and parts of Alaska.

GEOPHYSICS

Geophysics is the application of the principles of physics at or near the surface of the earth to determine the geology beneath the surface. General seismology is that branch of geophysics concerned with the study of earthquakes and the measurement of elastic properties of the earth. In exploration seismology, energy is transmitted into the earth and the recorded reflection provides the subsurface information for the delineation of geological structures.

The most common sources of energy for offshore seismic prospecting are air or gas guns which generate the seismic wave without the use of explosives. An array of various size guns provides sufficient energy to penetrate over 20,000 feet of formation in most areas.

The geophones that detect the reflected seismic energy are sensitive instruments enclosed in a cable up to 9,000 feet long which is towed behind a ship. The cable is a 4-inch-thick flexible tube which contains the geophones and the wires to carry the information to the recorders aboard ship. The cable is filled with oil to provide buoyancy and better acoustic coupling with the water and is fitted with

stabilizers to control its depth below the water (fig. 2).

The ship-borne equipment records the seismic signals on magnetic tape in digital format. These field data are processed in a digital computer to eliminate unwanted "noise" or random energy. After the data have been processed to obtain maximum quality, they are displayed in the form of a vertical cross section.

REGIONAL MAPPING

Prior to a call for nominations of tracts for leasing, geophysical service companies conduct regional geophysical surveys of an area of interest operating under a permit issued by the Geological Survey. These surveys provide a network of seismic lines for reconnaissance mapping. Geological Survey geophysicists undertake a regional interpretation of these data by mapping two or more seismic reflections corresponding to the depths of expected oil or gas production. These maps, which show the types of structures such as salt domes, anticlines, synclines, or faulting are used in selecting tracts to be offered for leasing.

DETAILED MAPPING

Once the tracts have been selected for leasing, a detailed evaluation of each tract is begun. If any wells have been drilled in the vicinity, geologists and paleontologists identify the depths of faults, their magnitude and direction, the depth and geological ages of prospective producing horizons, the depth of occurrence of paleontological markers or fossils, and their paleoecologic zone. During preliminary investigation, all evidence pointing to the presence of structural traps conducive to the accumulation of oil and gas is noted.

Geophysicists select at least two horizons to assure continuity in fault patterns and to show different rates and directions of dip. These horizons are selected at or near the productive zones found in any nearby wells or, alternatively, at the best seismic reflectors near specified paleontological markers. The depths to the reflector are transferred from the seismic sections to a map. Points of equal depths are joined by contours depicting the geologic structure in three dimensions. These maps identify potential reservoirs, along with the sand thickness and sand

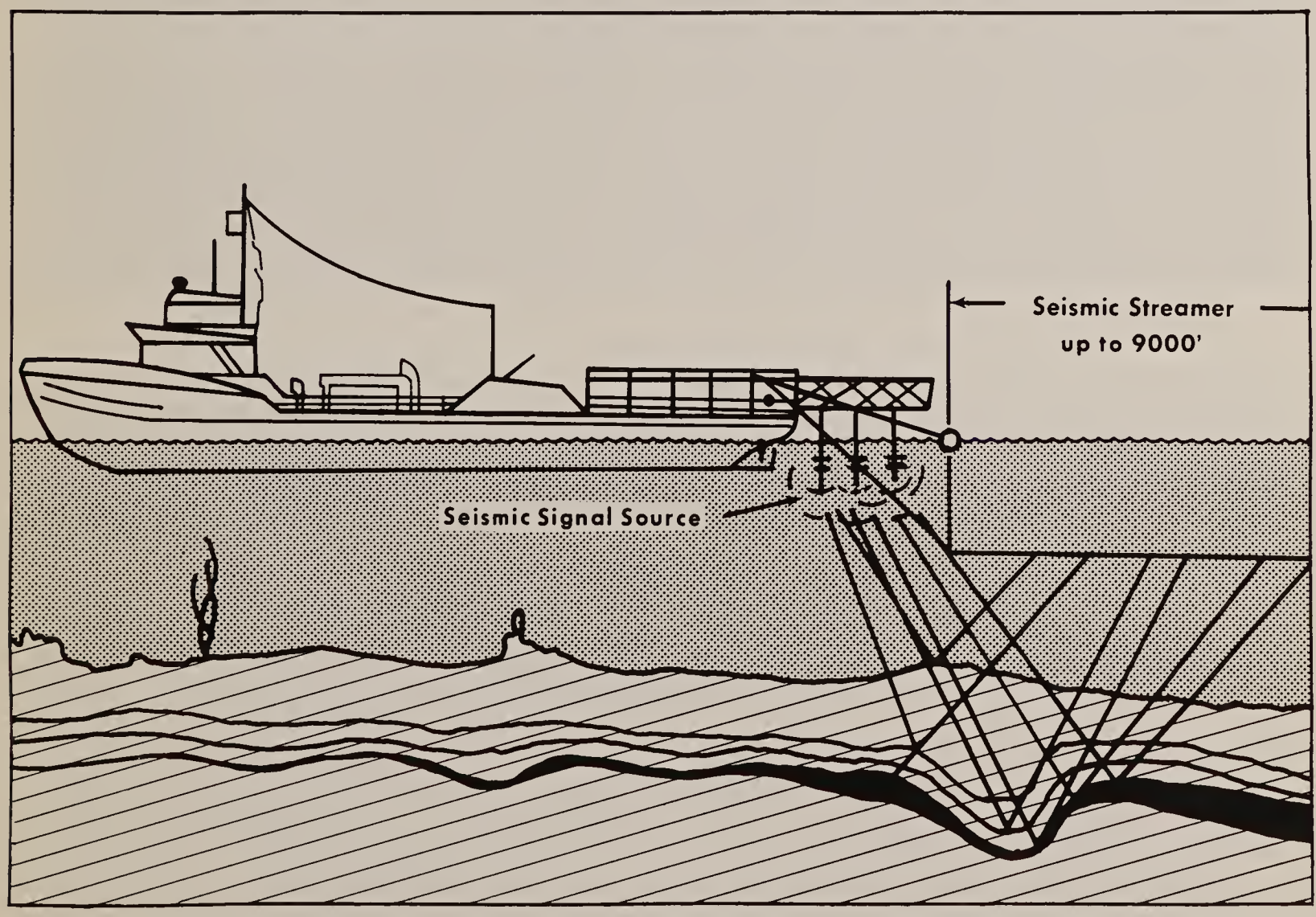

FIGURE 2.—Schematic diagram of a marine seismic prospecting system.

percentage data. Regionally and locally, seismic velocities in intervals of formation correlate with sand-to-shale ratios. Thus, even in the absence of information from wells, seismic structures may be evaluated as potential oil reservoirs from seismic structural and velocity information alone.

BRIGHT SPOT ANALYSIS

Ever since the discovery of petroleum, it has been the dream of prospectors to discover a means of determining the presence of oil or gas before drilling a well. Since late 1972, the best method to come into widespread use is a seismic process called "bright spots." Seismic reflections are caused by velocity changes in a formation. The greater the velocity difference between two geologic layers, the greater the amplitude of the reflected energy. Since the velocity in a gas- or oil-saturated sand is lower than in either a water-saturated or nonporous sand, the presence of oil or gas in the sand will cause a two- to five-fold increase in the amplitude of the reflected energy. By recording and processing the data in a manner that preserves the true amplitudes of reflections, it is possible to identify gas- or oil-bearing sands. These specially processed data are displayed on separate cross sections as an aid in interpretation of the prospect (figs. 3 and 4).

HIGH RESOLUTION SURVEYS

Shallow high resolution seismic data are used in Geological Survey programs in: (1) lease management for approving or rejecting plans of exploration or applications for permits to drill, (2) lease evaluation, (3) environmental impact assessment, (4) special studies, and (5) pollution prevention. Surface and shallow subsurface geologic hazards, when properly identified and correlated with surrounding strata, seldom prevent conducting a minimal risk program of exploration and development. High resolution data are used to detect fault scarps and salt domes that penetrate the sea floor, bottom irregularities, mud mounds, mud waves, potential slide areas, geologic unconformities, old river channels, shallow gas accumulations, and gas seeps.

Surface high resolution data are obtained with the side-scan sonar, which by recording reflected sound waves has the capability of identifying topographic irregularities, pipelines, and other objects on the sea floor. By comparing the intensity and shape of recorded echoes, various bottom materials can be identified.

GEOLOGY

The Geological Survey is delegated five major areas of geological investigation for resource evaluation of the Outer Continental Shelf; namely, data analysis and support, reserve estimates, tract evaluation, reservoir studies, and unitization. Reservoir studies and unitization are discussed later under Management of Leased Land. Each of these areas involves multidisciplinary tasks that are essential to the management of Federal offshore mineral resources.

DATA ANALYSIS AND SUPPORT

The Geological Survey conducts paleontological investigations including biofacies and paleoenvironmental studies and correlation utilizing biostratigraphic zones. Staff scientists examine cores and borings from wells to determine their relationship to Outer Continental Shelf mineral exploration. Drill cuttings are examined for correlation, geological age dating, and paleoecological data. Analysis of electrical well surveys (electric logs), cores, and thin sections of cores results in the preparation of comprehensive clastic and carbonate reports, maps, and cross sections.

Geological Survey scientists and engineers compile, correlate, and interpret subsurface geologic and geochemical data and prepare maps essential to the estimation of mineral resources and reserves. Rock units and biostratigraphic zones are located, identified, and traced; areal extent is mapped; and mineralogy, lithology, organic remains, and other physical characteristics are described. Specific subsurface studies are performed for prospective areas of lease sales by the preparation of sand and carbonate maps and the projection of known producing trends, structures, and provinces into Outer Continental Shelf areas. The Geological Survey prepares geologic summary reports and geologic framework descriptions for environmental impact statements.

RESERVE ESTIMATES

Detailed subsurface geologic studies, by Geological Survey scientists and engineers, identify lands subject to drainage, determine the areal extent and reserves of oil and gas reservoirs underlying unleased and undrilled lands, and assist in evaluating tracts for competitive lease sales. As development of a lease progresses, reserve estimates are refined and updated to assure conservation of the mineral resources to obtain maximum ultimate recovery.

TRACT EVALUATION

Tract evaluation requires geologic investigations to establish the fair market value of areas offered at a lease sale to aid in the decision to accept or reject bids. Such investigations provide subsurface geologic data, including net effective pay thicknesses, areal reservoir limits, hydrocarbon-water contacts, and sand occurrences which the reservoir engineer uses in his evaluation calculations. The results of these investigations are displayed as structural and isopachous (thickness) maps.

ENGINEERING

Reservoir engineering evaluation commences after geophysicists and geologists have interpreted and described the geologic nature of an oil and gas prospect. The engineer is concerned with the characteristics that determine the volume of oil and gas present and the economics of their recovery. Values for many individual geological and engineering factors of a reservoir cannot be measured directly before a tract is drilled, so estimates must be made of the value for each factor. Hence, a range of possible values for these factors must be considered.

The proper handling of uncertainty in the data is one of the most difficult tasks in the analytical evaluation process. The "range of values" concept recognizes that there is not a unique solution to the

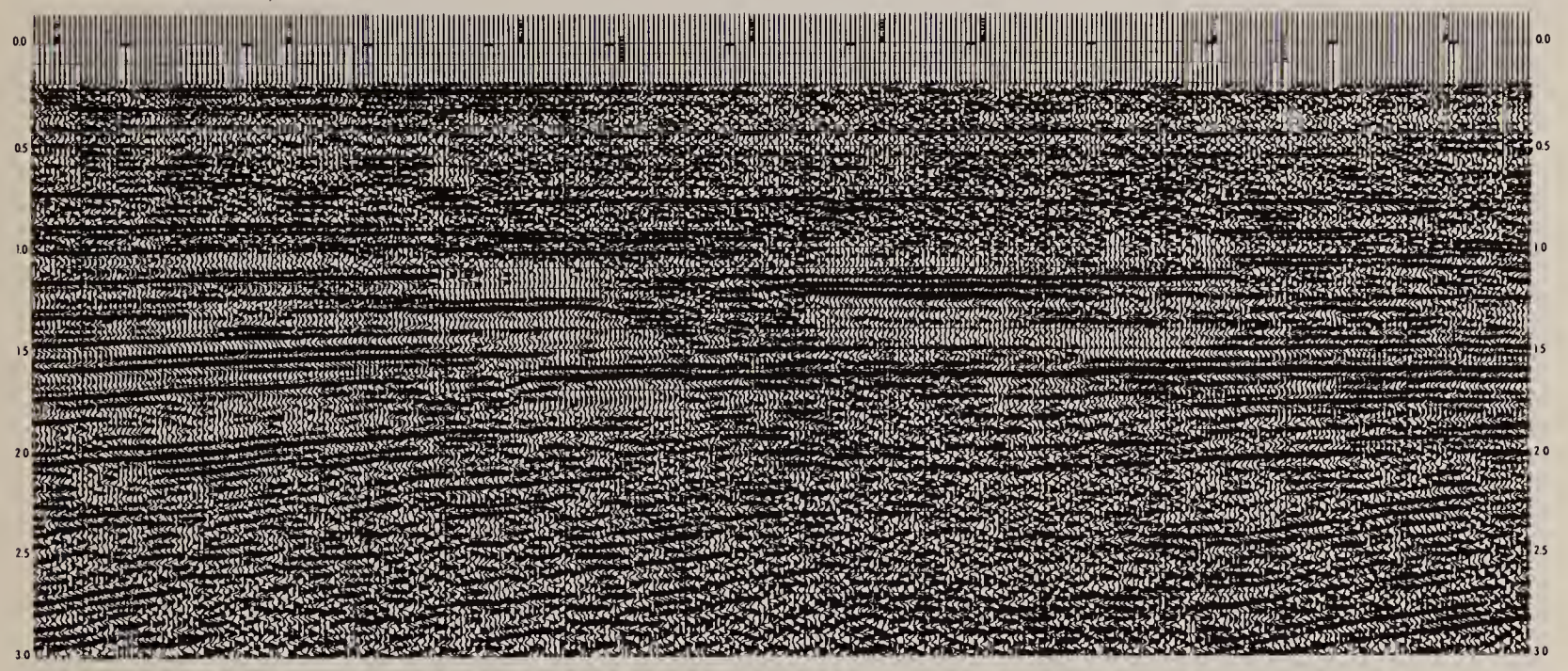

FIGURE 3.—Multifold seismic reflection data (standard processing). Courtesy of Teledyne Corporation.

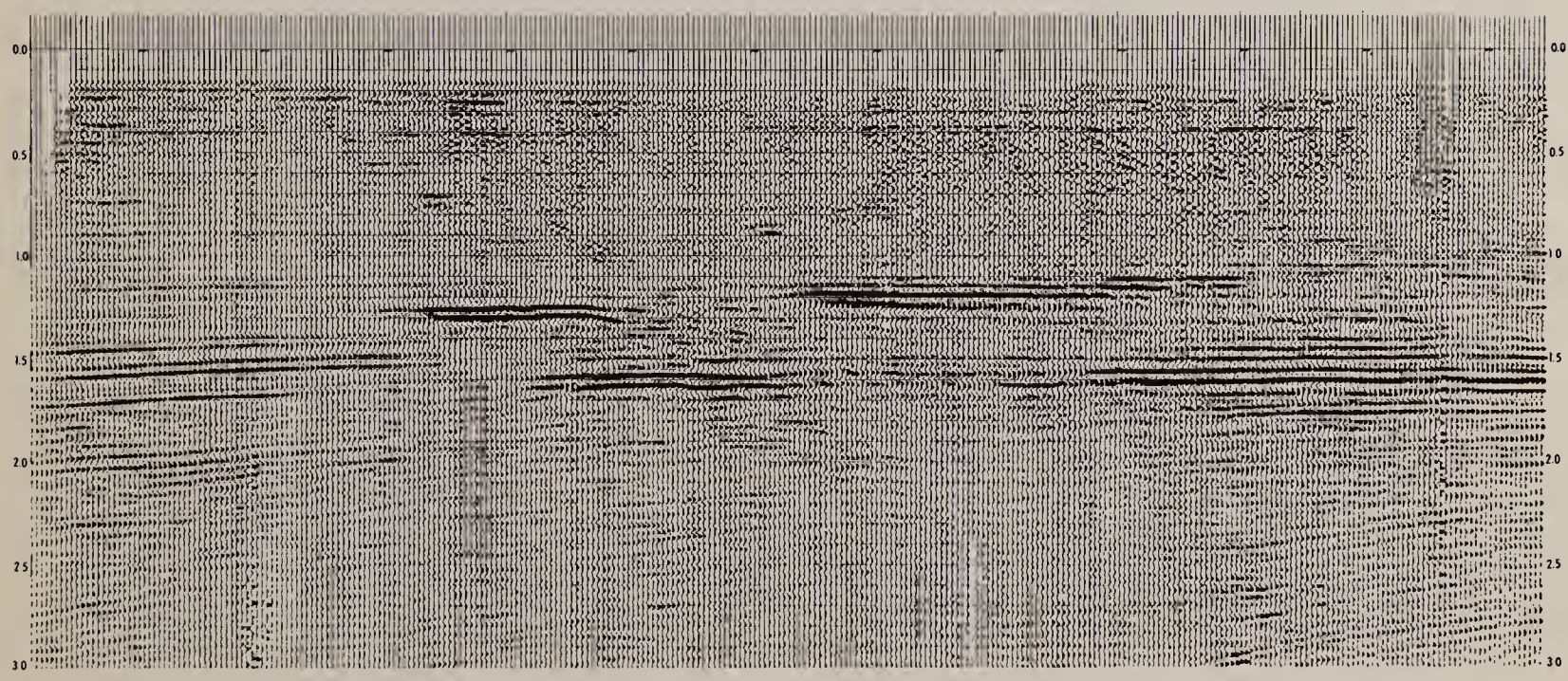

FIGURE 4.—Multifold seismic reflection data (high fidelity—bright spot—processing). Courtesy of Teledyne Corporation.

evaluation equation but rather an infinite number of possible solutions.

Thus, the Geological Survey works to correlate all available data—seismic reflection and bright-spot sections, near-surface high resolution and velocity data, and geologic and engineering information—to provide the best possible solution to offshore land classification and evaluation problems.

MANAGEMENT OF LEASED LANDS

The Geological Survey's lease management mission is concerned with personnel and equipment safety, conservation of resources, and prevention of pollution. Supervision is carried out through a set of rules and regulations that are implemented through field inspections and by review of applications and proposed plans.

OIL AND GAS LEASE CONTRACT

The oil and gas mineral lease grants the right to the lessee to conduct necessary operations to discover and produce petroleum from Outer Continental Shelf submerged lands. The lease also reserves to the lessor (U.S. Government) such rights as: leasing of other minerals, geological and geophysical exploration, rights-of-way, the right to take royalty in the amount or value of production, the authority to suspend operations and production, and the right to extract helium from all gas produced. The oil and gas lease further spells out requirements including surety bonding, royalty and rental payments, terms, and assignments. An oil and gas lease covers a compact area not exceeding 5,760 acres and the primary term is five years, continuing thereafter as long as oil and gas may be produced in paying quantities or approved drilling or well reworking operations are conducted.

SAFETY AND POLLUTION CONTROL

Assurance of safe clean operations is accomplished by implementation of the Code of Federal Regulations supplemented by Outer Continental Shelf Orders and Notices issued to the lessees and operators. The rules and regulations are frequently reviewed and revised through a process allowing for public, local government, and industry input to reflect changing technology and environmental and safety standards. These regulations define the responsibility and authority of the Geological Survey to regulate operations, to exercise control over drilling and production, and to require that equipment be adequate for the safe conduct of operations. The safe conduct of operations is accomplished by requiring the lessee to satisfy safety system and operating procedure requirements as specified in Regulations and Orders. The principal objectives of safety systems are threefold: (1) to prevent accidents, (2) to minimize the effects of accidents if they do happen despite precautions, and (3) to repair the damage that may result from a serious accident and prevent any permanent environmental effects. These objectives are applicable to the operation as a whole and to its component parts. They can also serve as criteria by which the adequacy of safety systems may be evaluated. In establishing safety system requirements, stress is placed on the development of redundancy by requiring back-up devices and procedures that provide for safety if a critical item of equipment fails (McKelvey, 1973).

SUPERVISION OF DRILLING OPERATIONS

Before drilling can be initiated, the lessee must submit an Application for Permit to Drill. The application must include a contingency plan for handling emergencies during drilling, such as spills and fires; a plan of exploration and development; significant geological markers anticipated; and specific information on such items as the drilling rig, casing design, cementing program, drilling fluid program, and blowout preventer equipment. Geological Survey geologists, geophysicists, and engineers review the application for compliance with orders and regulations and for potentially hazardous conditions that may be anticipated. Unusual hazardous conditions such as surface faulting, potential slide areas, shallow gas pockets, or deeper abnormal pressures are made known to the operator. If the possibility exists that a potential hazard might cause an accident during the drilling operation, the lessee may be required to change the drilling plan. Only after the Geological Survey is completely satisfied that safety and environmental requirements can be met will the permit to drill be approved.

Offshore drilling facilities used by the petroleum industry to explore, develop, and produce oil and gas can be categorized as fixed and mobile platforms. Fixed platforms are permanently attached to the ocean floor and are used primarily for development drilling and production operations (fig. 5). Mobile platforms are used for exploratory drilling and are at a given location for a limited period of time. They can be classified as bottom-founded, surface-type,

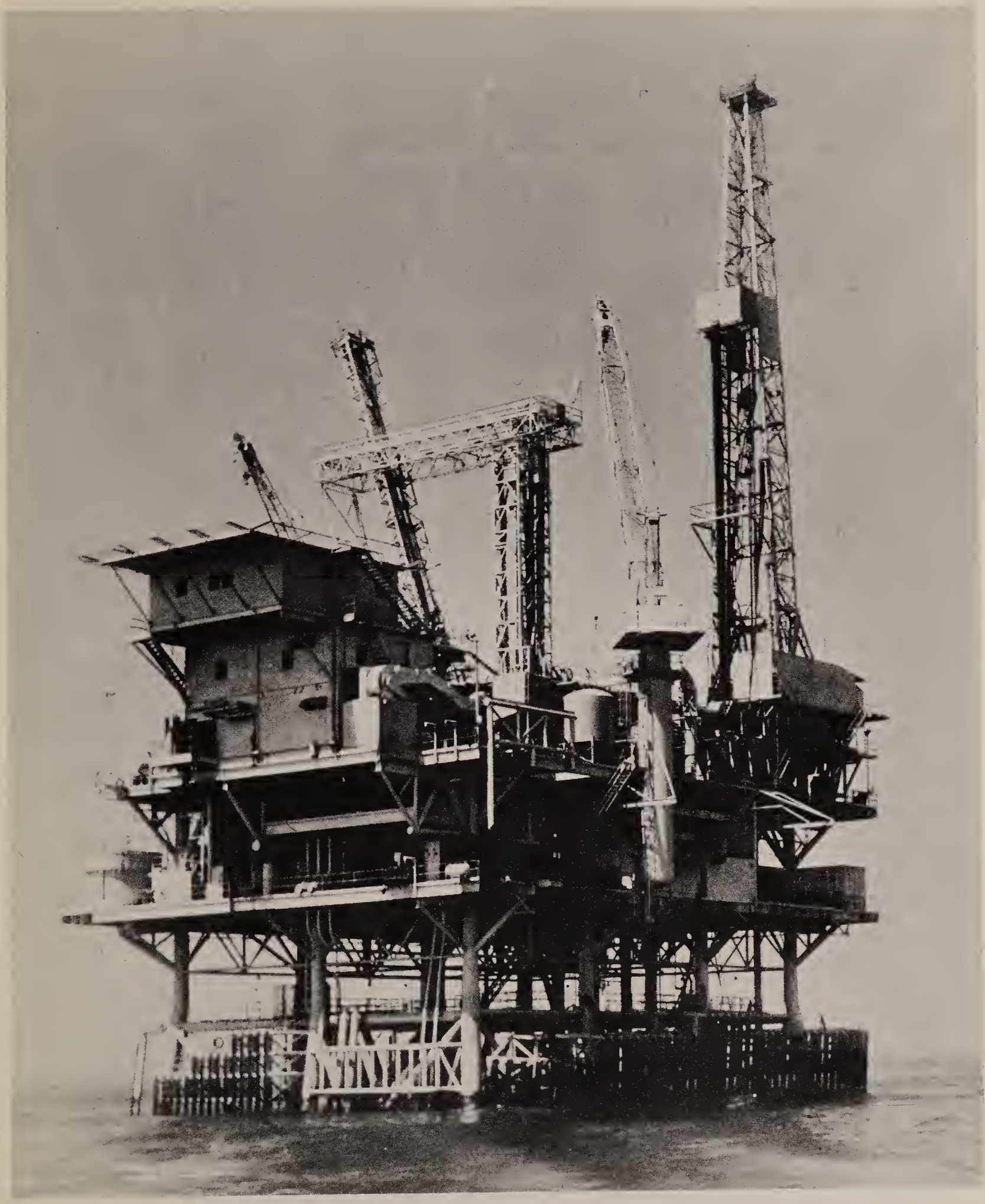

FIGURE 5.—Self-contained fixed drilling and production platform.

and column-stabilized. All drilling vessels are floated to location and are held in position by resting on the ocean floor or with an anchor system. The anchor system may consist of heavy anchors and anchor wires, a dynamic self-positioning system, or a combination of the two (Harris, 1972, p. 29–34).

Bottom-founded drilling units may be either self-elevating or submersible and both are limited to operation in relatively shallow water. The submersible drilling vessel is flooded until the hull rests on bottom. This type has been used extensively in the marshy areas of the Gulf of Mexico, but its capability is limited to very shallow water. The bottom-founded, self-elevating drilling vessel, commonly called a "jack-up," raises the hull out of the water with legs resting on the ocean floor. Units of this type are limited to a maximum water depth of 200 to 300 feet (fig. 6).

Surface-type drilling vessels may be either ship or barge units. Both types float on the surface of the water during drilling operations and are held on location by their anchoring system. They differ only in that the ship is self-propelled, whereas the barge must be towed to location. These vessels, commonly called "floaters," can drill in water depths as great as 2,500 feet, but they are subject to all of the motion of a floating object; namely, surge, sway, heave, roll, pitch, and yaw (fig. 7).

The column-stabilized, or semisubmersible, drilling vessel differs radically in appearance from traditional vessels. It has a platform or deck area that is supported by columns connected to large underwater displacement hulls, or vertical caissons, or a combination of the two. The basic purpose of the general design is to reduce wave forces by locating the major buoyancy members beneath the surface of the water. These vessels are subject to the same six motions as floating vessels but to a lesser degree because they have a natural roll period that is usually out of the range of motion-creating wave periods. These vessels may or may not be self-propelled and are maintained on location in a manner similar to the floating vessel. Their water-depth capability is comparable to that of the floating vessel (fig. 8).

Drilling vessels are modified by a center opening through the vessel, commonly called a "moonpool," for conducting drilling operations. All vessels are equipped with a drilling mast or derrick, hoisting equipment, rotary table, mud pumps and tanks, and other equipment necessary for drilling. The drilling equipment is essentially the same as that used for onshore drilling, but with some special modifications for operation in the marine environment.

Multiple development wells are drilled from an offshore platform in a gradual curve (deviated from the vertical) by controlled directional drilling. With this method, as many as 60 development wells can be drilled from one platform, thus reducing the number of platforms.

Exploratory wells are drilled in accordance with established guidelines. As the well is being drilled, casing and drilling fluid (mud) programs are followed as approved in the application. Drilling mud normally keeps the well under control. However, subsurface pressures greater than that exerted by the mud column can cause flow of subsurface fluids (oil, gas, or water) into the well bore. To control this flow, blowout preventers are required. The blowout preventer assembly is a series of large valves attached to the top of the casing (fig. 9). The Geological Survey has requirements for the use of remotely controlled, hydraulically operated blowout preventers during all drilling operations.

SUPERVISION OF PRODUCTION OPERATIONS

Applications to install drilling and production platforms and related equipment are reviewed to insure that the design is appropriate for the existing conditions. Geological Survey engineers perform systems design analysis to discover any potential hazards. The analysis includes the review of a mechanical flow and safety system schematic diagram to insure that the production system conforms to safety standards. The design of the structure, the production processing equipment, and the personnel facilities, together with incoming and departing pipelines, are checked against requirements to assure that these components will properly integrate into an effective platform safety system. A barrel of oil entering the well bore passes through a subsurface safety valve, an automatic fail-closed wellhead valve, a flowline which is protected by high- and low-pressure sensors, a check valve, hydrocarbon handling pressure vessels protected with high- and low-pressure and liquid level sensors, and shipping pumps protected by high- and low-pressure sensors. Any abnormal operating condition will result in an automatic production system shut-in. Pneumatic and hydraulic control systems are equipped with fusible links which melt in the event of fire and, as a result of the loss of pressure, activate fail-closed valves. Emergency shut-in controls, located at strategic points on the platform,

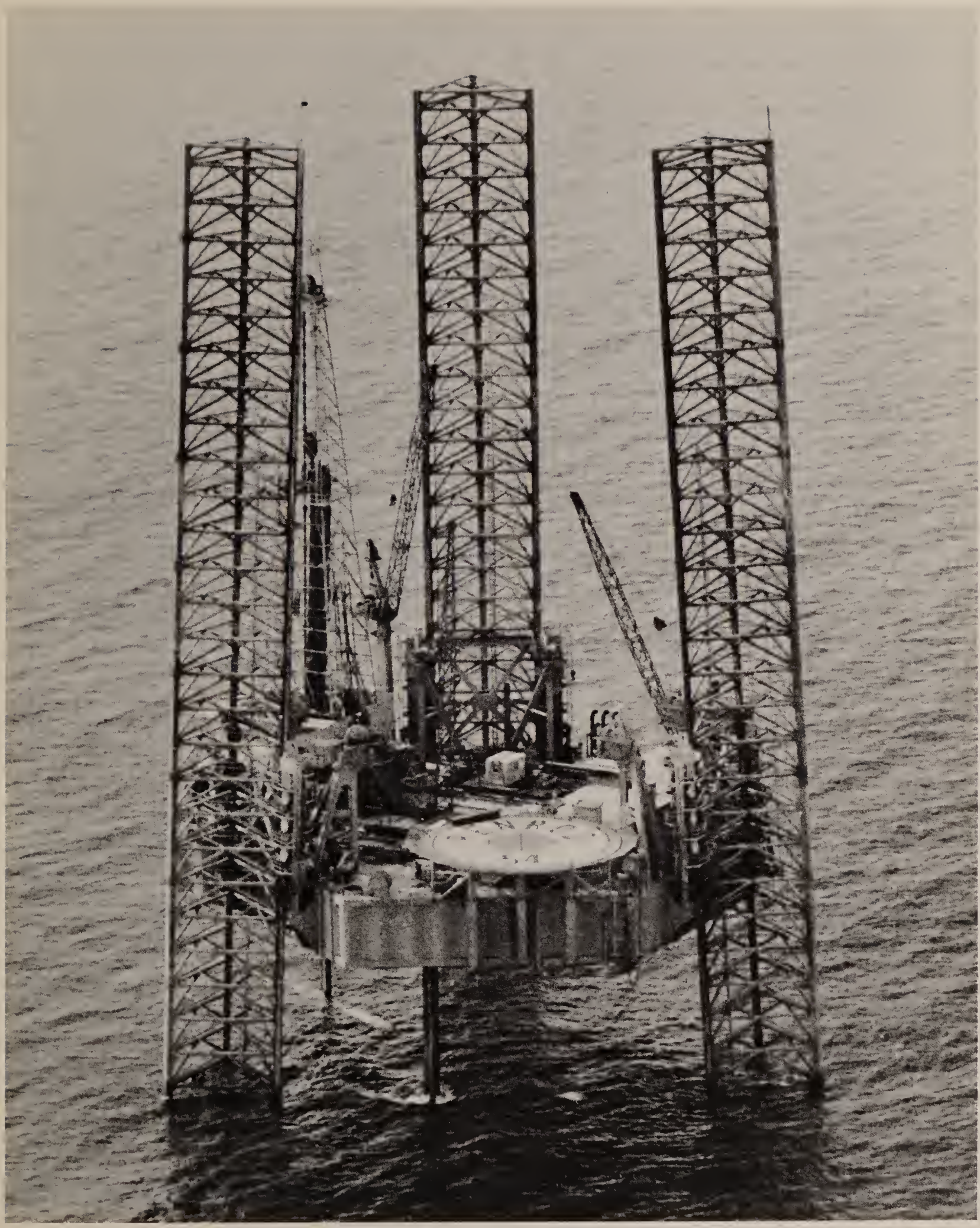

FIGURE 6.—Jack-up mobile drilling platform.

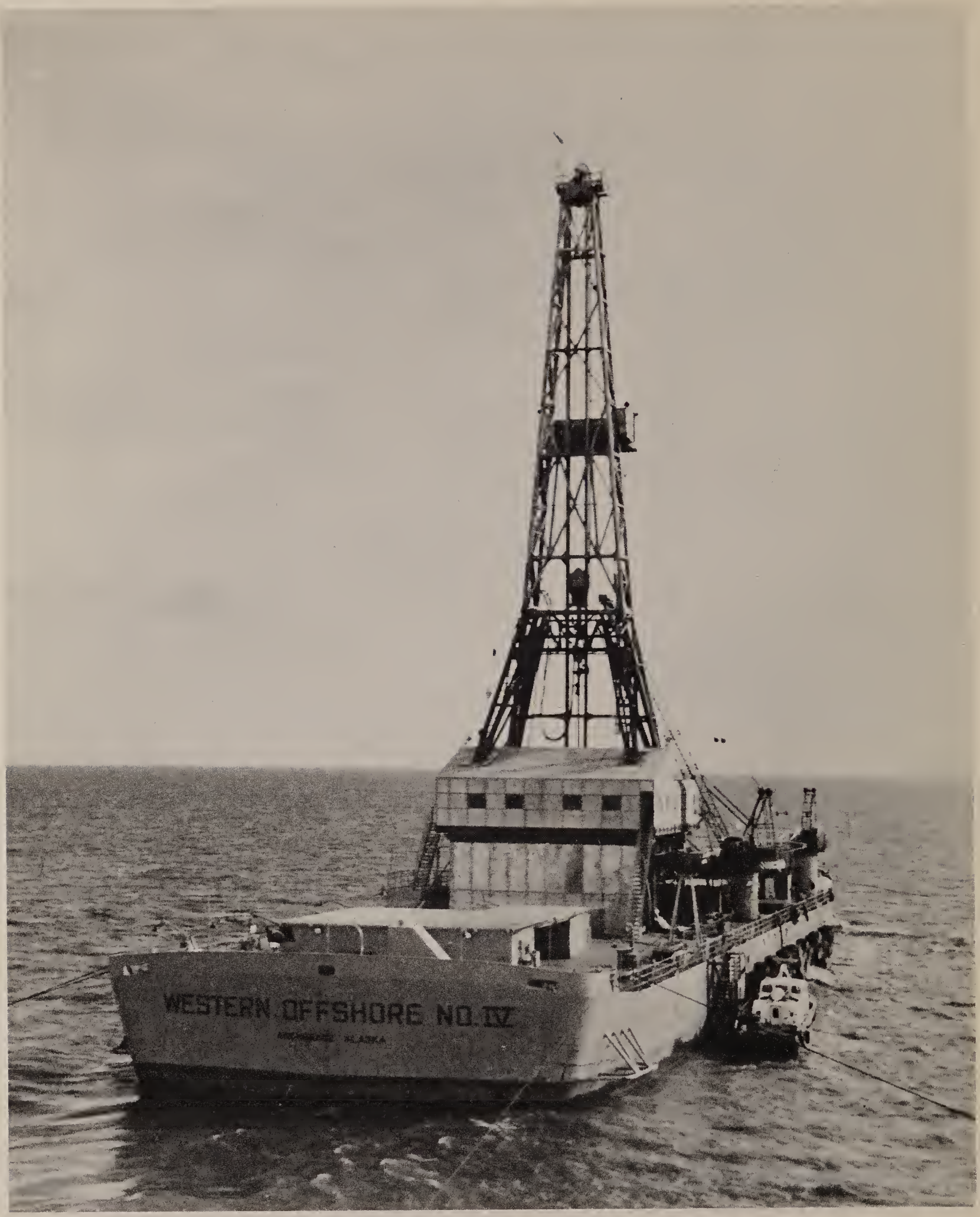

FIGURE 7.—Floating mobile drilling platform.

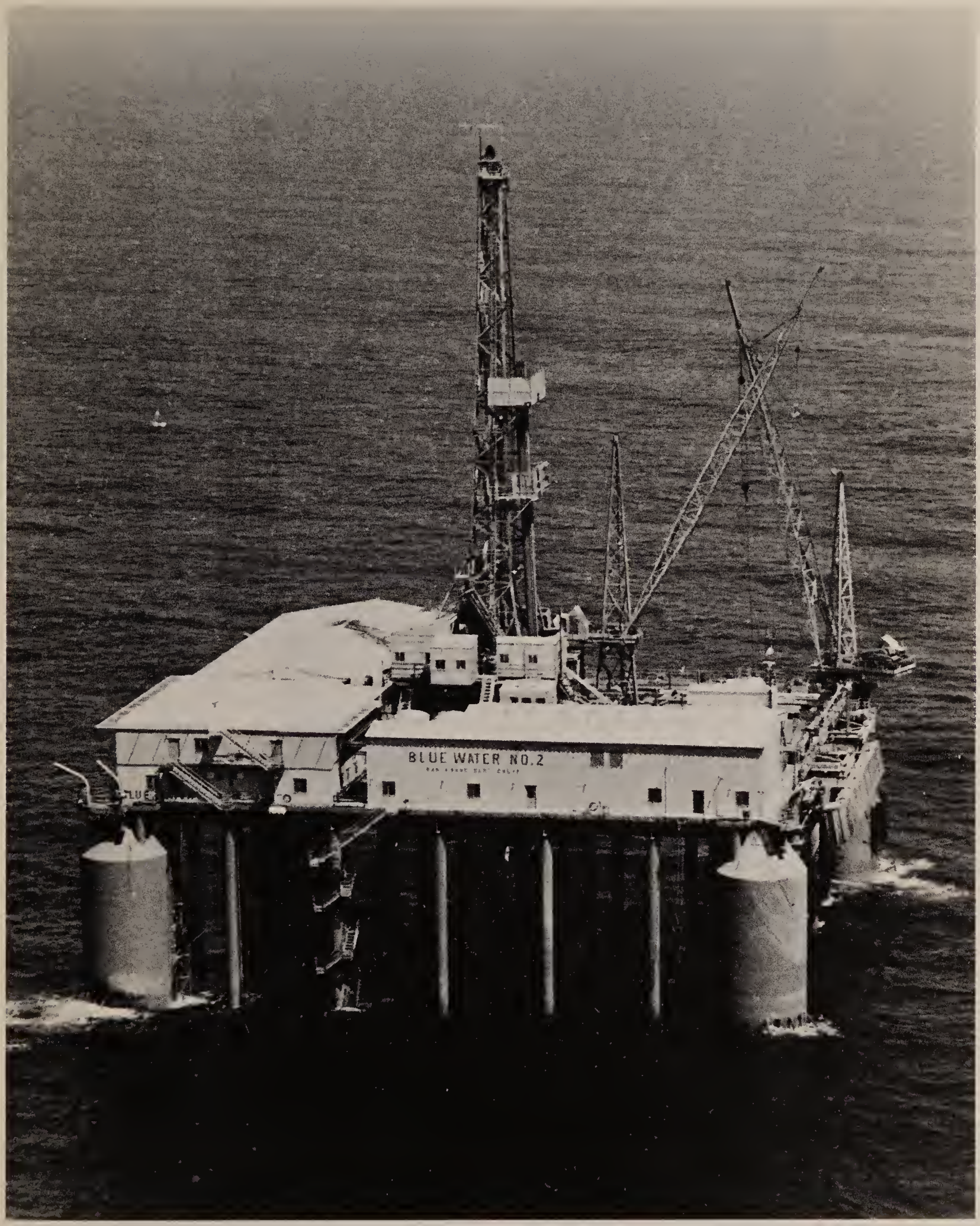

FIGURE 8.—Semi-submersible mobile drilling platform.

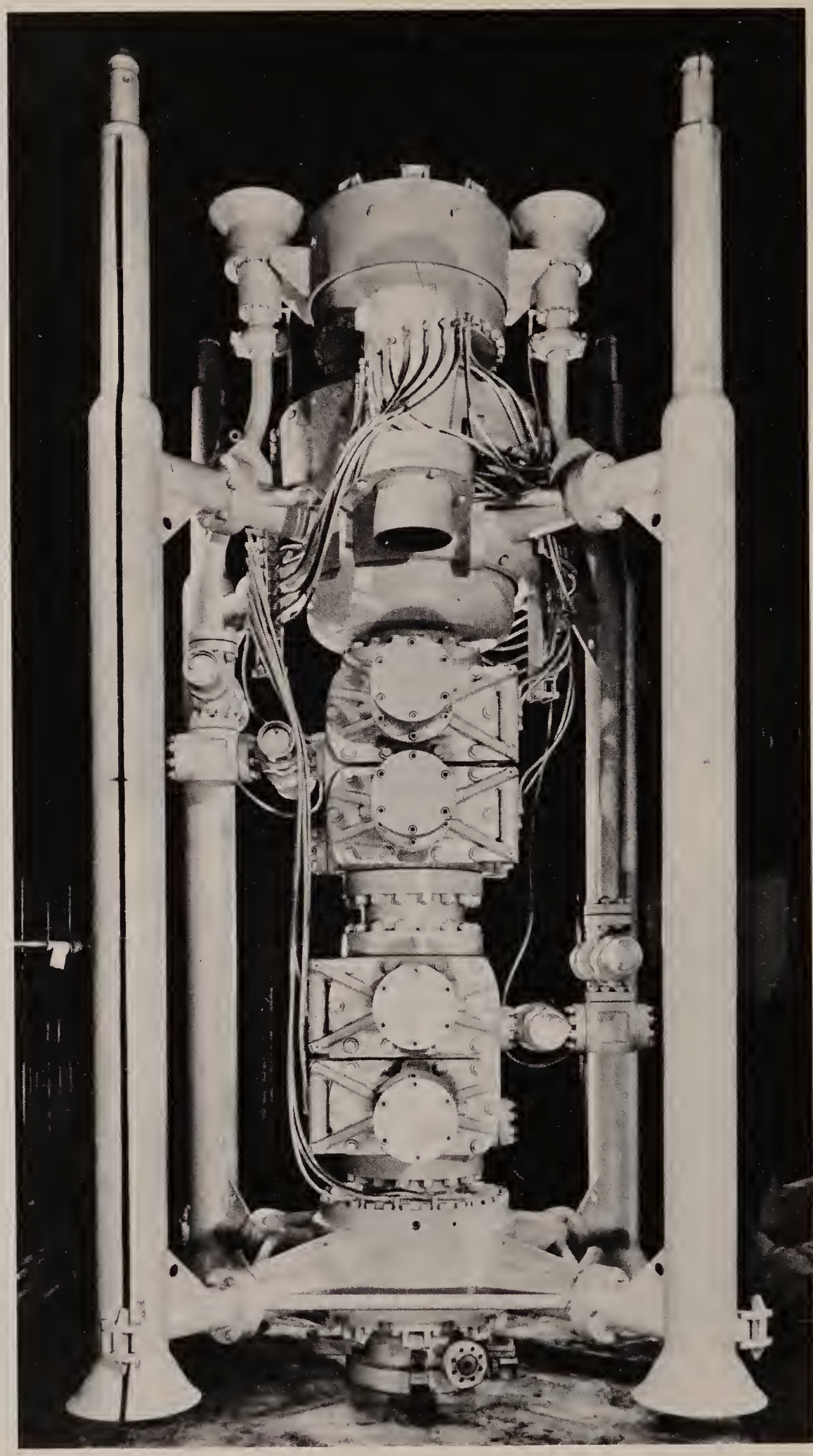

FIGURE 9.—Blowout preventer assembly for installation on the ocean floor.

are an integral part of the safety shut-in system and afford a backup means for manually effecting a complete shut-in of the entire facility. In addition to such manual controls at the central panel, others are located on the boat landing and helicopter pad for use in the event of an emergency evacuation of the facility.

After a development well is drilled and cased, the casing is perforated with shaped explosive charges or bullets to establish a path for oil or gas to flow from the formation into the well bore. Another string of pipe, called tubing, is run inside the casing as a conduit for the oil or gas to flow to the surface. Flow at the surface is controlled by a set of wellhead valves, commonly referred to as a "Christmas tree," placed on top of the tubing. The required subsurface safety valve is installed when the well is placed on production (fig. 10).

When a field is depleted and abandonment is necessary, the operator must plug the wells in accordance with Geological Survey requirements. All oil and gas zones must be isolated and any freshwater zones must be protected with cement plugs. An additional cement plug is required just below the ocean floor to further insure a permanent seal. All casing is cut off below the ocean floor and the location is cleared.

FIELD INSPECTION

The Geological Survey has the specific responsibility to inspect, monitor, and document the day-to-day activities and operations of the petroleum industry on the Outer Continental Shelf by on-site inspection and witnessing of the testing of safety and pollution control equipment. The inspection program administers a fair, but firm, uniform enforcement policy that insures conformance to standards that result in a safe, prudent, and pollution-free operation.

To facilitate inspections, the Outer Continental Shelf Orders and Regulations have been condensed into a checklist composed of questions that are answered by the inspection team either positively for compliance or negatively for noncompliance. Each incident of noncompliance requires that the inspector take a prescribed enforcement action which will result in either a warning or a shutdown of operations. If the incident results in a shutdown,

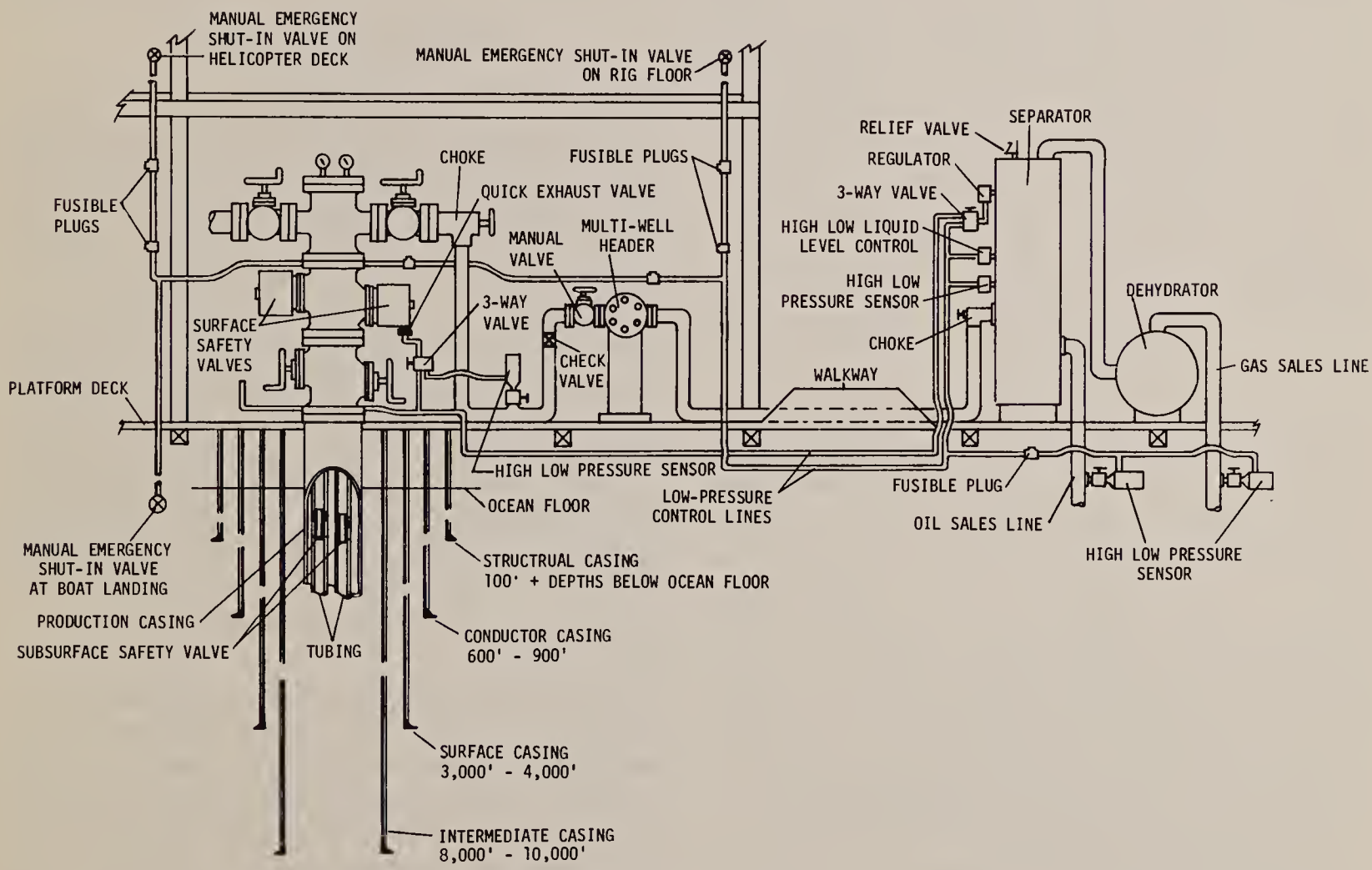

FIGURE 10.—Schematic diagram showing casing program and production safety system of a typical 12,000-foot well, Gulf of Mexico.

the condition must be corrected before operations can be resumed (Krahl and Moody, 1972; Solanas, 1973).

The checklist used by the inspectors is a listing of potential incidents of noncompliance, or "PINC's." The actual incidents of noncompliance observed, termed "INC's," are counted at each inspection site, and the INC to PINC ratio is used as a basic measurement of the degree of compliance. Results of inspections are shown in table 10.

Inspection teams of petroleum engineering technicians visit Outer Continental Shelf facilities, traveling to the activities by helicopter and boat, observing the water surface for any incidents of pollution while enroute. Additional flights are made for the sole purpose of pollution detection. Inspections of drilling rigs and related equipment in the Gulf of Mexico are conducted at least once during the drilling of each wildcat well and during drilling of the first development well from a platform. New production facilities are inspected upon commencement of operations. All major platforms are scheduled for inspection semi-annually. All drilling rigs and production platforms in the Dos Cuadras Field in the Santa Barbara Channel are inspected daily.

Blowouts, fires, pipeline leaks, and other accidents are investigated by the inspection teams. These investigations establish the contributing factors in accidents in order to avoid similar future incidents. The Geological Survey has instituted a "Safety Alert" program to inform all operators of the probable cause of accidents. "Safety Alert" notices are sent to all Outer Continental Shelf operators to provide details of a hazardous situation that has resulted in an accident. This information enables operators not involved in a particular incident to evaluate similar situations in their operations, and thus, help eliminate potentially hazardous situations.

TABLE 10.—*Distribution of ratios of incidents of non-compliance to potential items of non-compliance by event class observed during December 1970 through April 1974 inspections of production sites*

Inspection	Event class					Total
	Blowout	Pollution	Fire	General Safety	Others	
December 1970	.003	.127	.165	.009	.216	.166
February 1971	-	.032	.044	.019	.016	.020
March	.002	.036	.033	0	.016	.018
April	0	.021	.001	0	.011	.010
June1/	-	.020	-	-	.001	.012
July1/	-	.040	-	-	.012	.028
August	0	.020	0	0	.003	.006
September2/	0	.025	.001	0	.001	.006
November1/	-	.036	-	-	0	.017
January 1972	0	.012	.005	0	.001	.004
March1/	-	.021	-	-	.013	.018
May 1/	-	.013	-	-	0	.013
August 1/	-	.014	-	-	.010	.014
September	0	.021	0	0	.001	.005
November	0	.016	.003	0	.004	.005
January 1973 1/	0	.024	.009	0	.001	.019
March1/	0	.034	.023	0	0	.026
June	.004	.018	0	0	.001	.005
September1/	0	.034	.051	0	0	.028
November	.002	.025	.002	0	.008	.010
April 1974 1/	0	.024	.008	-	.005	.013

1/ Partial inspections were made during June, July, and November 1971; March, May, and August 1972; January, March, and September 1973; and April 1974.

2/ Complete inspections of previously inspected sites were made during September 1971.

RESOURCE CONSERVATION

UNITIZATION

Even though oil and gas are finely distributed throughout the pore spaces of the host rock in which they accumulate, the accumulations are commonly but improperly called pools, or reservoirs, several of which may occur within a single field.

Frequently a single reservoir may underlie leases belonging to two or more separate owners, causing a strong motivation for each competing owner to produce as much oil and gas as possible from his own lease before the reservoir is exhausted. In the past this situation has led to much needless and costly drilling and large scale waste of oil and gas. A number of conservation measures have been instituted to curb such wasteful practices. An especially effective conservation measure is that of unitization.

Unitization is the practice of pooling all interest, ownership, and control in a prospective or producing oil and gas field, or part of a field, through an agreement which provides for development and operation of the property as a unit by a single operator. Unitization can be used to maximize oil and gas recovery from competitively operated pools, to eliminate the drilling of

unnecessary wells, to reduce development and production costs, and to protect the correlative rights of operators, lessees, and royalty interest owners. The majority of secondary recovery operations cannot be initiated effectively in competitively operated oil and gas reservoirs without unitization.

Unitization results in unified exploration, development, and exploitation of the reservoir, field, or area as a unit under one control. Ownership of production is in proportion to the percentage interest ascribed to each reservoir and each lessee shares in production and expenses of the unit.

A role of the Geological Survey as a regulatory agency is to encourage voluntary unitization, to effect involuntary unitization where it is deemed necessary for conservation purposes, and to administer and supervise operations in approved unitized areas. Administering and initiating unitization plans involves geologic and engineering studies of areas in need of unitization, proposal of equitable allocation of participation in unitized areas, review of proposed plans of exploration and development, development of standard forms of unitization agreements, and reveiw and approval of unitization agreements (table 11).

PRODUCTION CONTROL

The maximum efficient rate of an oil and gas reservoir is the maximum rate at which hydrocarbons may be withdrawn without causing damage to the reservoir. Production at rates in excess of the maximum efficient rate results in the dissipation of reservoir energy to no useful good and the reduction of the total amount of oil and gas which may ultimately be recovered. Maximum efficient rates may be predicted by geological and engineering studies, physical or simulated reservoir models, or a combination of both.

In its task of conserving natural resources, the Geological Survey determines and establishes maximum efficient rates of production for the oil and gas reservoirs on the Outer Continental Shelf.

ROYALTY ACCOUNTING

The accounting staff collects rents and royalties, audits leasehold royalty accounts, and accounts for the sale of royalty oil taken in kind and sold to small refiners. Production procedures are monitored from the time Outer Continental Shelf products are produced and transported through pipelines or barge systems to onshore measurement and sales points. The amount and value of all products are determined to assure receipt of fair market value. Royalties from the sale of liquid hydrocarbons extracted by gas processing plants are reveiwed for accounting accuracy. Fair market value for royalty purposes is based on such factors as posted price, price received by the lessee, and highest price paid for a part or majority of production of like quality in the same field. For production data see tables 12, 13, and 14.

EFFORTS TO INCREASE OPERATIONAL MARGIN OF SAFETY

Overall oil industry response to the task of improving safety and antipollution aspects of Outer Continental Shelf operations has been one of willing cooperation. Ongoing projects which will increase the operational margin of safety in the future are being implemented. Although impossible to quantify, the oil industry has made substantial expenditures to comply with the rigid requirements established by the Geological Survey in the past five years. Even greater safety is expected in the future.

At the request of the Geological Survey, studies of Outer Continental Shelf operations were conducted by an in-house group of systems analysts, a team of quality control and management specialists from the National Aeronautics and Space Administration, and the Marine Board of the National Academy of Engineering. These studies, as well as a subsequent technological study made by an interdisciplinary research team at the University of Oklahoma and an environmental assessment made by the Council on Environmental Quality, were evaluated by a Geological Survey work group. The studies and evaluations have been the foundation upon which both industry and government projects aimed at insuring safer operations have been established.

The overall program for increasing Outer Continental Shelf safety is reviewed by the Geological Survey at the district, area, regional, and headquarters levels. The internal efforts are reviewed by a committee which operates under the auspices of the Marine Board of the National Academy of Engineering.

The American Petroleum Institute, and industry trade association, has created permanent committees for equipment standardization, personnel training, and research programs relating to Outer Continental Shelf safety and antipollution efforts. The Standardization Committee is developing equipment standards which will include quality-control requirements. The Research Committee is recommending and overseeing safety and antipollution research projects. The Training and

Motivation Committee is attacking one of the most difficult projects, that of insuring that personnel are properly trained and motivated to carry out safely all tasks involved in marine oil and gas drilling and production operations.

FUTURE OUTER CONTINENTAL SHELF ACTIVITY

STATISTICAL BACKGROUND

Since the passage of the Submerged Lands Act and the Outer Continental Lands Act in 1953, development of oil and gas production in the offshore waters of the United States has progressed substantially. With onshore production declining, it is probable that future development of the offshore areas will proceed at an accelerated rate.

From the Outer Continental Shelf, offshore Louisiana oil and gas production started in 1953, offshore Texas oil production started in 1955 and gas production in 1966, and offshore California oil and

TABLE 11.—*Unit plans and percentage of unitized production Outer Continental Shelf, calendar years 1956 through 1973*
[After Harris, W. M. Piper, S. K., and McFarlane, B. E., 1974]

Year	Unit plans						Percentage of total production	
	Approved 1/		Terminated 1/		Outstanding			
	Number	Acreage	Number	Acreage	Number	Acreage	Oil	Gas
1956	11	314,172	-	-	11	314,172	4	-
1957	2	35,477	1	38,250	12	311,399	11	-
1958	1	22,500	-	-	13	333,899	20	-
1959	4	104,400	1	22,499	16	415,800	23	-
1960	-	5,001	1	52,501	15	368,300	28	3
1961	1	15,000	1	35,047	15	348,253	34	7
1962	-	-	-	-	15	348,253	37	13
1963	1	22,270	-	-	16	370,523	37	15
1964	5	94,144	-	1,260	21	463,407	38	16
1965	7	198,753	-	-	28	662,160	37	16
1966	16	317,176	1	273	43	979,063	38	28
1967	7	171,702	3	127,820	47	1,022,945	40	32
1968	3	29,803	1	51,600	49	1,001,148	40	30
1969	29	49,279	-	24,062	78	1,026,365	40	27
1970	18	96,083	3	101,864	93	1,020,584	43	27
1971	7	4,166	2	72,606	98	952,144	37	27
1972	15	87,963	13	71,405	100	968,702	37	26
1973	15	136,690	3	51,981	112	1,053,411	34	24
Through 1973	142	1,704,579	30	651,168	112	1,053,411	37	24

1/ Includes expansions and contractions of unit plan agreements.

gas production started in 1968; offshore Alaska has yet to initiate either oil or gas production. Through 1973, production of oil from the Outer Continental Shelf has amounted to 54 percent of the total offshore production, and production of gas has amounted to 73 percent (tables 12 and 13).

In 1953, the production of crude oil and condensate from the Outer Continental Shelf amounted to only 0.05 percent of the total United States production and gas production amounted to 0.24 percent. By 1973, the figure for crude oil and condensate had increased to 11.76 percent of the total United States production and that for gas to 14.02 percent of the total (table 14).

AREAL EXTENT AND LOCATION

The continental margin (fig. 11) is the submerged extension of a continent from the shoreline to the abyssal depths of the adjoining ocean. The continental margin consists of the continental

TABLE 12.—*Total offshore state and federal oil and condensate production, in thousands of barrels*
[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

Year	Alaska			California			Louisiana			Texas			Total		
	Thousands of Barrels	Percent		Thousands of Barrels	Percent		Thousands of Barrels	Percent		Thousands of Barrels	Percent		Thousands of Barrels	Percent	
		State	OCS		State	OCS		State	OCS		State	OCS		State	OCS
Prior	-	-	-	422,385	100	-	54,803	98	2	-	-	-	477,188	100	-
1954	-	-	-	32,665	100	-	15,926	79	21	10	100	-	48,601	93	7
1955	-	-	-	33,252	100	-	25,731	74	26	156	99	1	59,139	89	11
1956	-	-	-	32,348	100	-	40,906	73	27	140	90	10	73,394	85	15
1957	-	-	-	30,561	100	-	52,835	70	30	256	98	2	83,652	81	19
1958	-	-	-	28,363	100	-	57,381	57	43	470	100	-	86,214	71	29
1959	-	-	-	26,787	100	-	72,793	51	49	499	100	-	100,079	64	36
1960	-	-	-	28,074	100	-	88,122	44	56	567	100	-	116,763	57	43
1961	-	-	-	29,887	100	-	103,197	38	62	292	100	-	133,376	52	48
1962	-	-	-	34,613	100	-	126,801	29	71	803	100	-	162,217	45	55
1963	-	-	-	38,346	100	-	149,087	30	70	669	92	8	188,102	44	56
1964	6	100	-	40,526	100	-	173,709	29	71	578	99	1	214,819	43	57
1965	30	100	-	42,772	100	-	199,293	27	73	557	99	1	242,652	40	60
1966	2,650	100	-	53,294	100	-	243,080	23	77	1.246	29	71	300,270	37	63
1967	15,937	100	-	64,807	100	-	284,033	23	77	3,400	16	84	368,177	40	60
1968	52,530	100	-	85,339	98	2	329,922	20	80	3,400	9	91	471,191	43	57
1969	60,887	100	-	96,145	90	10	365,691	18	82	3,109	11	89	525,832	41	59
1970	70,007	100	-	104,283	76	24	398,378	16	84	3,046	26	74	575,714	37	63
1971	66,152	100	-	101,717	69	31	444,363	13	87	2,885	42	58	615,117	32	68
1972	63,749	100	-	95,418	76	24	452,584	14	86	3,035	43	57	614,786	33	67
1973	61,715	100	-	89,218	79	21	429,465	13	87	3,018	46	54	583,416	32	68
Total	393,663	100	-	1,510,800	93	7	4,108,100	24	76	28,136	40	60	6,040,699	46	54

Source: Bureau of Mines, Alaska Scouting Service, Conservation Committee of California, Louisiana State Mineral Board, Louisiana Department of Conservation, and Texas Railroad Commission.
Louisiana and Texas are estimated in part.

terrace and the continental rise. The continental terrace consists of the relatively gently sloping continental shelf and the more steeply dipping continental slope. The continental rise is that portion of the continental margin from the base of the continental slope to the abyssal depths of the ocean. The continental rise dips more steeply than the continental shelf but less steeply than the continental slope.

The total area of the world's continental margin is about 28.8 million square miles or 18.4 billion acres. The continental shelf occupies about 10.5 million square miles or 6.7 billion acres and the continental slope covers about 10.9 million square miles or 7 billion acres. The continental rise covers about 7.41 million square miles or 4.74 billion acres. The total area of the continental margin makes up about 20.6 percent of the world's ocean floor or an area of more

TABLE 13.—*Total offshore state and federal gas production, in millions of cubic feet*

[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

Year	Alaska			California			Louisiana			Texas			Total		
		Percent			Percent			Percent			Percent			Percent	
	MMCF	state	OCS	MMCF	state	OCS	MMCF	state	OCS	MMCF	state	OCS	MMCF	state	OCS
Prior	-	-	-	-	100	-	91,675	78	22	-	-	-	91,675	78	22
1954	-	-	-	-	100	-	81,325	31	69	3,440	100	-	84,765	34	66
1955	-	-	-	-	100	-	121,279	33	67	6,880	100	-	128,159	37	63
1956	-	-	-	-	100	-	136,527	39	61	6,880	100	-	143,407	42	58
1957	-	-	-	-	100	-	160,472	49	51	13,765	100	-	174,237	53	47
1958	-	-	-	-	100	-	233,967	45	55	24,080	100	-	258,047	51	49
1959	-	-	-	-	100	-	329,280	37	63	24,080	100	-	353,360	41	59
1960	-	-	-	1,113	100	-	408,388	33	67	30,960	100	-	440,461	38	62
1961	-	-	-	5,903	100	-	458,481	31	69	13,760	100	-	478,144	33	67
1962	-	-	-	10,671	100	-	588,361	23	77	41,280	100	-	640,312	29	71
1963	-	-	-	25,769	100	-	706,545	20	80	30,960	100	-	763,274	26	74
1964	-	-	-	35,323	100	-	783,474	21	79	30,960	100	-	849,757	27	73
1965	10	100	-	40,770	100	-	871,124	26	74	27,520	100	-	939,424	31	69
1966	1,200	100	-	46,839	100	-	1,265,899	24	76	59,259	29	71	1,373,197	27	73
1967	8,324	100	-	46,732	100	-	1,655,223	34	66	127,473	22	78	1,837,752	35	65
1968	22,844	100	-	86,565	99	1	2,057,291	31	69	154,631	29	71	2,321,331	34	66
1969	44,393	100	-	81,326	94	6	2,478,745	26	74	240,212	47	53	2,844,676	31	69
1970	82,369	100	-	71,225	83	17	2,800,104	19	81	264,420	50	50	3,218,118	25	75
1971	83,750	100	-	60,484	74	26	3,219,200	18	82	387,245	67	33	3,750,679	26	74
1972	74,982	100	-	44,830	78	22	3,480,831	17	83	156,772	6	94	3,757,415	19	81
1973	72,526	100	-	37,581	81	19	3,614,892	15	85	159,000	6	94	3,883,999	17	83
Total	390,398	100	-	595,131	91	9	25,543,083	23	77	1,803,577	48	52	28,332,189	27	73

Source: Bureau of Mines, Alaska Scouting Service, Conservation Committee of California, Louisiana State Mineral Board, Louisiana Department of Conservation, and Texas Railroad Commission.

Louisiana and Texas are estimated in part.

than half of the land area of the earth (McKelvey and others, 1969).

For the conterminous 48 states of the United States, the continental sea beds out to the 8,200-foot water depth cover 532,900 square miles or 341,056,000 acres. In addition, there are 795,100 square miles or 508,864,000 acres adjacent to Alaska and 4,000 square miles or 2,560,000 acres adjacent to Hawaii. Of the total area of the continental sea bed adjacent to the United States, 853,300 square miles or

TABLE 14.—*Total United States and Outer Continental Shelf production of crude oil and condensate, and gas, and percentage of OCS production of total United States production*

[After Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974]

Year	Crude oil and condensate production			Gas production		
	Thousands of barrels		OCS percent	Millions of cubic feet		OCS percent
	Total U.S.	Total OCS	of U.S.	Total U.S.	Total OCS	of U.S.
1953	2,357,082	1,151	.05	8,396,916	19,881	.24
1954	2,314,988	3,342	.14	8,742,546	56,325	.64
1955	2,484,428	6,705	.27	9,405,351	81,279	.86
1956	2,617,283	11,015	.42	10,081,923	82,893	.82
1957	2,616,901	16,070	.61	10,680,258	82,574	.77
1958	2,448,987	24,769	1.01	11,030,298	127,693	1.16
1959	2,574,590	35,698	1.39	11,619,951	207,156	1.78
1960	2,574,933	49,666	1.93	12,771,038	273,034	2.14
1961	2,621,758	64,330	2.45	13,254,025	318,280	2.40
1962	2,676,189	89,737	3.35	13,876,622	451,953	3.26
1963	2,752,723	104,579	3.80	14,666,559	564,353	3.85
1964	2,786,822	122,500	4.40	15,462,143	621,731	4.02
1965	2,848,514	144,969	5.09	16,039,753	645,589	4.03
1966	3,027,763	188,714	6.23	17,206,628	1,007,447	5.86
1967	3,215,742	221,862	6.90	18,171,325	1,187,216	6.53
1968	3,329,042	268,996	8.08	19,322,400	1,524,178	7.89
1969	3,371,751	312,860	9.28	20,698,240	1,954,487	9.44
1970	3,517,450	360,646	10.25	21,920,642	2,418,677	11.03
1971	3,453,914	418,549	12.12	22,493,000	2,777,043	12.55
1972	3,455,000	411,886	11.92	22,532,000	3,038,555	13.49
1973	3,356,000	394,730	11.76	22,900,000	3,211,588	14.02
Total	60,401,860	3,252,774	5.39	321,271,618	20,651,932	6.43

Source: Total United States production - MINERALS YEARBOOK and mineral industry surveys, Bureau of Mines. 1973 total United States production data are preliminary and subject to change.

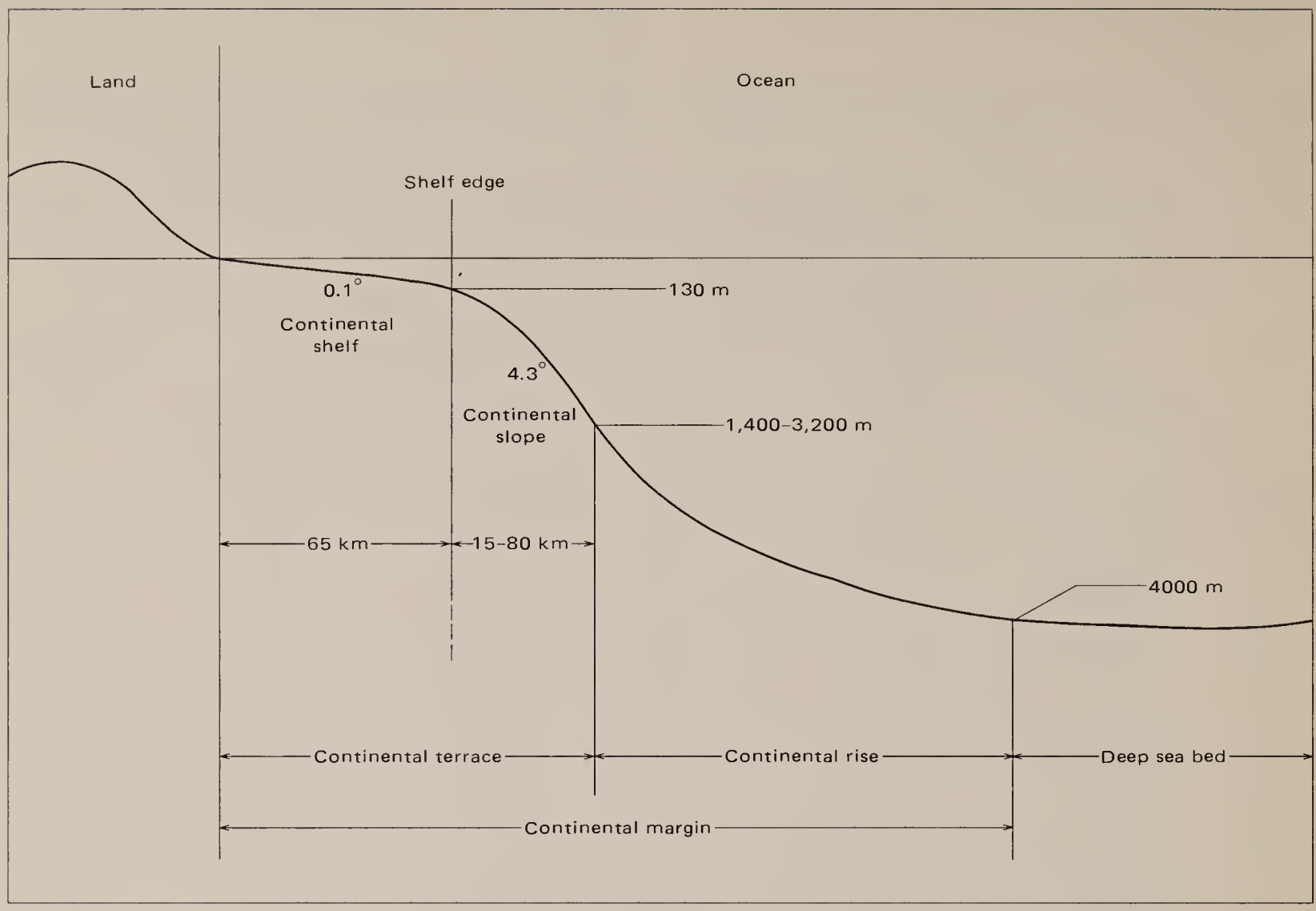

FIGURE 11.—Profile of the continental margin. Numbers shown are worldwide averages. After McKelvey, Stoertz, and Vedder (1969).

546,112,000 acres are between the shoreline and the 656-foot water depth. The remaining 478,700 square miles or 306,368,000 acres are located between the 656-foot and 8,200-foot water depths. The portion of the continental sea bed in State areas accounts for 48,000 square miles or 30,720,000 acres of the area out to the 656-foot water depth (table 15).

The base of the continental slope occurs at an average depth of about 8,200 feet. As mentioned earlier, the world's continental terrace, which includes the continental shelf and the continental slope, covers an area of 21,400,000 square miles. Therefore, the 1,332,000 square miles adjacent to the United States amounts to 6.22 percent of the world total.

LEAD TIME

For oil or gas to be discovered, developed, and marketed in a usable energy form requires a lead time of several years. Usually by the time a lease is issued, most of the detailed geological and geophysical investigations have been completed. Exploratory drilling may result in a commercial discovery early in the life of a lease or it may occur near the end of the 5-year, primary term. On the average, if a lease does prove productive, the discovery will be made in the

TABLE 15.—*Continental seabeds adjacent to the United States (Thousands of square statute miles)*

[After U.S. Department of the Interior, 1969]

Region	State lands[1/]	Between State limit and 200 metre depth	Between 200 and 2,500 metre depths	Total
Hawaii	--	0.4[2/]	3.6	4.0
Alaska	22.9	560.0	212.2	795.1
Pacific Coast	4.5	15.4	76.2	96.1
Gulf Coast	13.5	107.5	84.2	205.2
Atlantic Coast	7.1	122.0	102.5	231.6
Total	48.0	805.3	478.7	1,332.0

1/ Areas within 3 nautical miles of coastline, except for Texas and the Gulf Coast of Florida where the boundaries are 3 leagues distant.

2/ Includes State areas.

range of 1.5 to 4.5 years after the lease sale. In response to a survey by the Bureau of Land Management (U.S. Bur. Land Management, 1974), 25 oil and gas or related companies made estimates of the time period required, after discovery, to achieve initial and peak production in 17 Outer Continental Shelf areas. These companies estimated that it would take on the order of 2.5 to 6.5 years to attain initial production and 5.5 to 9.5 years to reach peak production. The total time, after a lease sale, to achieve initial production would be in the range of 4 to 11 years, and to attain peak production would be in the range of 7 to 14 years.

CONCLUSIONS

The foregoing discussion of the management of the mineral resources of the Outer Continental Shelf leads to the following conclusions:

- Production of oil and gas from the Outer Continental Shelf of the United States has increased substantially over the past 20 years.
- The oil and gas production from the Outer Continental Shelf represents an increasing percentage of the total United States production as onshore production has declined and offshore production has increased.
- Whereas exploration for oil and gas in the onshore portion of the United States has proceeded for more than 115 years, extensive offshore exploration has been limited to the past 25 years.
- Because of the accelerated pace of offshore exploration, the present state of offshore development approximately corresponds to the stage of onshore development that existed during the second decade of this century.
- Energy demands are increasing at an accelerated pace and technology has improved correspondingly.
- Improved technology and enforcement of more stringent regulations have made offshore operations safer, but it is unrealistic to believe that completely accident-free operations can ever be achieved.
- With expanded offshore development, the management of the mineral resources of the Outer Continental Shelf will become an increasingly significant function.
- While the United States has only slightly more than six percent of the world's continental terrace, only a small portion has been explored. Hopefully, further exploration will be fruitful and will aid the Nation in attaining a position of self-sufficiency.
- Because of increasing demands for energy, it is probable that production of oil and gas will not be sufficient to meet long-term requirements. However, based on current technology in the production of energy, oil and gas are the best short-term energy forms available.
- The lead time for the development of offshore oil and gas resources is on the order of a decade from the time of the lease sale to peak production.

SELECTED REFERENCES

Adams, M. V., 1972, Regulation and supervision of Outer Continental Shelf operations on the Pacific coast: Offshore Technology Conf., 4th Ann., Houston, Tex., 1972, Paper 1713, 9 p.

Berryhill, H. L., Jr., 1974, The worldwide search for petroleum offshore—a status report for the quarter century 1947–72: U.S. Geol. Survey Circ. 694, 27 p.

Harris, L. M., 1972, An introduction to deepwater floating drilling operations: Tulsa, Okla., Petroleum Publishing Company.

Harris, W. M., Piper, S. K., and McFarlane, B. E., 1974, Outer Continental Shelf statistics—oil, gas, sulfur, salt, leasing, drilling, production, income, 1953 through 1973, calendar year 1973: U.S. Geol. Survey Conserv. Div. Spec. Rept., 83 p.

Krahl, R. B., and Moody, D. V., 1972, Gulf coast lease management inspection program: Offshore Technology Conf., 4th Ann., Houston, Tex., 1972, Paper 1714, 6 p.

Marine Board, National Academy of Engineering, 1972, Outer Continental Shelf resource development safety: a review of technology and regulation for the systematic minimization of environmental intrusion from petroleum products: 197 p.

McKelvey, V. E., 1973, Environmental protection in offshore petroleum operations: Amsterdam, Netherlands, Elsevier Sci. Publishing Company, Ocean Management, v. 1, p. 119–128.

McKelvey, V. E., Stoertz, G. E., and Vedder, J. G., 1969, Subsea physiographic provinces and their mineral potential, *in* Subsea mineral resources and problems related to their development: U.S. Geol. Survey Circ. 619, p. 1–10.

National Aeronautics and Space Administration, 1971, Applicability of NASA contract quality management and failure mode effect analysis procedures to the USGS Outer Continental Shelf oil and gas lease management program: NASA rept. to U.S. Geol. Survey, 36 p., November.

Offshore, 1974, Count of all wells drilled in U.S. waters alltime to January 1, 1974: Offshore, v. 34, no. 7, p. 90.

Oklahoma University Technology Assessment Group, Kash, D. E., chm., 1973, Energy under the oceans: Oklahoma Univ. Press, Oklahoma Univ. Sci. Public Policy Program Rept., 378 p.

Solanas, D. W., 1973, Update—OCS lease management program: Offshore Technology Conf., 5th Ann., Houston, Tex., 1973, Paper 1754, 10 p.

U.S. Bureau of Land Management, 1974, Report on the responses received in reply to the request for comments on potential future Outer Continental Shelf oil and gas leasing: 48 p.

[U.S.] Council on Environmental Quality, 1974, OCS oil and gas—An environmental assessment: Washington, D.C., Council Environmental Quality Rept. to the President, v. 1, 214 p.

U.S. Department of the Interior: 1969, Petroleum and sulfur on the U.S. Continental Shelf: 61 p.

U.S. Geological Survey, 1972, Outer Continental Shelf lease management study—Safety and pollution control: Washington, D.C., U.S. Geol. Survey Water Resources Div. Systems Lab. Group rept., 116 p.

U.S. Geological Survey, 1973, Report of the Work Group on OCS Safety and Pollution Control [May 1973]: Washington, D.C., 35 p.

———1974a, Final environmental statement, proposed plan of development Santa Ynez Unit, Santa Barbara Channel, off California: U.S. Geol. Survey FES 74–20, v. 1, 421 p.

———1974b, Supplement No. 1 to the report of the Work Group on OCS Safety and Pollution Control [May 1973]: Washington, D.C., 26 p., May 1974.

———1974c, Supplement No. 2 to the report of the Work Group on OCS Safety and Pollution Control [May 1973]: Washington, D.C., 13 p., May 1974.

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

☆U.S. GOVERNMENT PRINTING OFFICE: 1975—677-313/56

ADAMS AND OTHERS—MINERAL RESOURCE MANAGEMENT OF THE OUTER CONTINENTAL SHELF—GEOLOGICAL SURVEY CIRCULAR 720

RECEIVED
AUG 4 1975
USGS SECTION

RECEIVED
4 1975
SECTION